THIRTEENTH ANNUAL REPORT

OF THE

EXPERIMENT STATION

AT THE

Kansas State Agricultural College.

FOR FISCAL YEAR 1899-1900,

INCLUDING

Bulletins 90 to 98, and Index.

MANHATTAN KANSAS.
1900.

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KANSAS STATE AGRICULTURAL COLLEGE,
MANHATTAN, KAN., November 1, 1900.

To his Excellency W. E. Stanley, Governor of Kansas:

DEAR SIR—I herewith transmit, as required by act of congress approved March 7, 1887, the Thirteenth Annual Report of the Experiment Station of the Kansas State Agricultural College, for the year ending June 30, 1900, including the financial statement for that period.

Respectfully,

E. R. NICHOLS,
Secretary Board of Regents.

KANSAS STATE AGRICULTURAL COLLEGE.

BOARD OF REGENTS.

Hon. E. T. FAIRCHILD, President,
Ellsworth, Ellsworth county.

Hon. J. S. McDOWELL, Vice-president,
Smith Center, Smith county.

Hon. W. T. YOE, Treasurer,
Independence, Montgomery county.

Hon. WM. HUNTER, Loan Commissioner,
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Hon. J. M. SATTERTHWAITE,
Douglass, Butler county.

Hon. CARL VROOMAN,
Parsons, Labette county.

President E. R. NICHOLS, Secretary *ex officio.*

EXPERIMENT STATION STAFF.

COUNCIL.

E. R. NICHOLS, A. M.,
Chairman *ex officio.*

J. T. WILLARD, M. S.,
Chemist and Director.

A. S. HITCHCOCK, M. S.,
Botanist.

PAUL FISCHER, B. AGR., M. V. D.,
Veterinarian.

H. M. COTTRELL, M. S.,
Agriculturist.

E. A. POPENOE, A. M.,
Horticulturist and Entomologist.

LORENA E. CLEMONS, B. S., Secretary.

ASSISTANTS.

D. H. OTIS, M. S. ..... Assistant in Dairying.
PERCY J. PARROTT, A. M. ..... Assistant Entomologist.
R. W. CLOTHIER, M. S. ..... Assistant Chemist.
J. M. WESTGATE, M. S. ..... Assistant Botanist.
ALBERT DICKENS, B. S. ..... Assistant Horticulturist.
J. G. HANEY, B. S. ..... Assistant in Feeding and Field Work.
A. T. KINSLEY, B. S. ..... Assistant in Veterinary Department.

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EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

THIRTEENTH ANNUAL REPORT—FISCAL YEAR 1899-'00.

FINANCIAL STATEMENTS.

Report of the Treasurer.

July 1, 1899, to June 30, 1900.

To the Board of Regents of the Kansas State Agricultural College:

GENTLEMEN—Herewith is submitted my report of receipts and expenditures on account of the Experiment Station for the period between July 1, 1899, and June 30, 1900:

Received from the treasurer of the United States	$15,000 00
Received from cash sales of products	7,002 05
Total	$22,002 05
Approved vouchers Nos. 1 to 449, including credits	21,393 66
Balance	$608 39

W. T. YOE, *Treasurer.*

Report of the Secretary.

To the Board of Regents of the Kansas State Agricultural College:

GENTLEMEN—Herewith is submitted the following report of the financial affairs of the Experiment Station of the Kansas State Agricultural College for the year ending June 30, 1900, as prepared under directions from the United States Department of Agriculture. The several items of this account are covered by vouchers approved by the disbursing officer, certified by the Secretary, and allowed by the President and the Board of Regents.

Experiment Station, Kansas State Agricultural College, in account with the United States appropriation, 1899–1900.

DR.

To receipts from the treasurer of the United States as per appropriation for fiscal year ending June 30, 1900, as per act of congress approved March 2, 1887	$15,000 00

CR.

By salaries	$6,931 59
Labor	3,556 68
Publications	340 03
Postage and stationery	264 16
Freight and express	160 43
Heat, light, and water	91 09
Chemical supplies	187 35
Seeds, plants, and sundry supplies	408 52
Fertilizers	9 55
Feeding stuffs	736 31
Library	267 64
Tools, implements, and machinery	70 26
Furniture and fixtures	79 95
Scientific apparatus	209 84
Live stock	1,195 49
Traveling expenses	76 98
Contingent expenses	11 64
Building and repairs	402 49
Total	$15,000 00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Experiment Station, Kansas State Agricultural College, for the fiscal year ending June 30, 1900; that we have found the same well kept and classified as above; and that the receipts for the year from the treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000; for all of which proper vouchers are on file, and have been by us examined and found correct, thus leaving no balance.

And we further certify, that the expenditures have been solely for the purposes set forth in the act of congress approved March 2, 1887.

(Signed) W. T. YOE,
[SEAL.] E. T. FAIRCHILD,
J. S. MCDOWELL,
ATTEST: E. R. NICHOLS, *Custodian.* *Auditors.*

Supplementary Statement.

Dr.

To receipts from other sources than the United States for the year ending June 30, 1900: Farm and garden products	$7,002 05

Cr.

Salaries	$658 51
Labor	451 49
Publications	36 87
Postage and stationery	9 95
Freight and express	96 05
Chemical supplies	5 10
Seeds, plants, and sundry supplies	58 14
Feeding stuffs	1,072 82
Library	10 27
Scientific apparatus	68 70
Live stock	3,918 46
Contingent expenses	7 30
Total	$6,393 66
Balance	608 39
Grand total	$7,002 05

Respectfully submitted.

Lorena E. Clemons.

Expenditures by Departments, 1899–1900.

Items.	Farm.	Horticultural and entomological.	Chemical.	Botanical.	Veterinary.	General.	Total.
By salaries	$1,940 00	$1,556 10	$1,485 00	$1,149 00	$900 00	$560 00	$7,590 10
Labor	1,352 57	1,150 86	478 63	370 98	291 32	363 81	4,008 17
Publications	149 38	34 14	10 80	33 86	4 15	144 57	376 90
Postage and stationery	31 75	16 50	8 89	16 48	78 75	121 74	274 11
Freight and express	110 47	18 38	33 04	7 90	54 75	31 94	256 48
Heat, light, and water	.....	.....	58 32	.....	32 77	.....	91 09
Chemical supplies	.....	33 79	78 02	.....	80 64	.....	192 45
Seeds, plants, and sundry supplies	60 29	123 51	81 43	113 72	64 68	23 03	466 66
Fertilizers	.....	9 55	.....	.....	.....	.....	9 55
Feeding stuffs	1,792 40	.....	.....	.....	16 73	.....	1,809 13
Library	.....	22 94	37 00	182 68	31 29	4 00	277 91
Tools, implements, and machinery	69 86	.....	.....	40	.....	.....	70 26
Furniture and fixtures	.....	18 10	.....	.....	53 00	8 85	79 95
Scientific apparatus	.....	15 63	64 91	.....	198 00	.....	278 54
Live stock	5,113 95	.....	.....	.....	.....	.....	5,113 95
Traveling expenses	42 97	21 74	.....	.....	12 27	.....	76 98
Contingent expenses	.....	.....	.....	5 00	1 64	12 30	18 94
Building and repairs	396 00	2 40	.....	4 09	.....	.....	402 49
Totals	$11,059 64	$3,023 64	$2,336 04	$1,884 11	$1,819 99	$1,270 24	$21,393 66

REPORT OF THE COUNCIL.

To the Board of Regents of the Kansas State Agricultural College:

GENTLEMEN—We present, to accompany the financial statements, the following account of the Station work for the fiscal year ending June 30, 1900, as a part of the annual report of the Station to the governor required by law.

Changes in Organization.

Owing to the changed relation of the officers of the College and the Experiment Station to their duties, by reason of the increased demands upon their personal attention caused by the great growth of the College during the time that has elapsed since the organization of the Station, it has been apparent for some time that advantageous changes might be made in the organization of the Station in respect to its general business. With this fact in view, the following recommendation of the Council was presented to the Board of Regents, and was adopted by them January 18, 1900:

The Experiment Station shall be managed by a Council, to consist of the president of the College, who shall be chairman *ex officio*, an agriculturist, a botanist, a chemist, an entomologist and horticulturist, a veterinarian, and such others as the Board of Regents may designate. A member of the Council, named by the Board, shall be styled director. He shall be the executive officer of the Station, and as such shall attend to its general business and correspondence, the printing, binding and distribution of its publications, and such other matters as the Board or Council may direct, but in all things shall be subject to the action of the Council. All experiments shall be undertaken with the advice and consent of the Council, but the details of their performance shall be under the control of the departments in charge of them respectively. The Council shall hold regular monthly meetings, and such special meetings as may be necessary.

The provisions above set forth are those which have governed the action of the Council throughout the year, even before their formal adoption. The changes in administration involved thereby are detailed in the report of the general department.

The Staff.

The Station Council has remained nearly the same as least year. President Will's connection with the College ceasing, Professor Willard, chemist of the Station, was made chairman of the Council July 13, 1899. Upon recommendation of the Council, the Board of Regents, January 18, 1900, revived the office of director, and appointed Profes-

sor Willard thereto. At the same time the President of the College was designated to be a member of the Council, and its chairman. In accordance therewith, Professor Nichols, Acting President, and later President, has officiated in the capacity named since that date. The vacancy caused by the resignation of Professor Faville was filled by the appointment of Prof. E. A. Popenoe to the position of horticulturist and entomologist, from July 1, 1899. Professor Popenoe had been a member of the Council from the establishment of the Station until 1897. Miss Lorena Clemons succeeded Mr. W. H. Phipps as Secretary of the College and of the Experiment Station July 1, 1899.

In the force of assistants, J. M. Westgate succeeded Geo. L. Clothier as assistant botanist July 1. July 12, Acting Assistant J. G. Haney was made assistant in feeding and field work, and Albert Dickens was appointed to succeed W. L. Hall as assistant horticulturist. January 20, 1900, A. T. Kinsley was appointed assistant in the veterinary department.

Publications.

The publications of the Station during the year consist of the Twelfth Annual Report, Bulletins 90 to 98, Press Bulletins 46 to 70, a summary of the weather observations each month, and a few mimeograph bulletins. The following is an outline of the report and bulletins and a list of the press bulletins, showing the department issuing the publication, the number of copies printed, and date of issue:

Annual Report.

Twelfth Annual Report, February, 1900, 3000 copies. This consists of the financial statements, an outline of the bulletins, and a list of the press bulletins issued during the year, reports of work in progress, and a general statement concerning the progress and condition of the Station. A list of the publications of the Station to the end of the fiscal year is appended.

Bulletins.

Bulletin 90. January, 1900. Farm Department. 20,000 copies.

Alfalfa in Eastern Kansas.—This bulletin details the method of starting alfalfa in regions that have become foul with weeds, and general directions for treatment of the plant.

Bulletin 91. February, 1900. Veterinary Department. 20,000 copies.

Swine-plague.—Discusses the principles of protective inoculation as a preventive of disease; the outbreak of swine-plague in the College herd, its causes and progress; whether or not the virus used in protective inoculation can produce the disease; the difficulty of detecting the presence of swine-plague in its early stages, and the value of an observation of the temperature of suspected

animals; the danger attending the purchase of miscellaneous lots of swine and bringing them together.

BULLETIN 92. March, 1900. Farm Department. 30,000 copies.

A New Drought-resisting Crop—Soy-beans.—Gives a description of soy-beans, methods of planting, culture, and harvesting; discusses their value in feeding, and outlines a number of experiments in which they formed a part of the ration fed; recommends them for trial because of their effect on the soil and the high protein content of the crop.

BULLETIN 93. March, 1900. Farm Department. 30,000 copies.

Kafir-corn.—Discusses this crop in all its aspects; varieties, planting, cultivation, harvesting, yield, resistance to drought, composition; feeding value for swine, dairy cows, calves, horses, and sheep; Kafir-corn as a hay crop; danger of second growth; objections to it; regions where it should be grown.

BULLETIN 94. April, 1900, Chemical and General Departments. 25,000 copies.

Sugar Beets, 1899; The Station Publications, with Partial Index.—This bulletin gives the results of the analyses of sugar beets grown in 1899 in cooperation with the chemical department. It also contains a complete list of all the publications of the Station to date, and an index to the more important subjects treated therein.

BULLETIN 95. April, 1900. Farm Department. 25,000 copies.

Fattening Hogs with Drought-resisting Crops.—Gives the details of feeding thirty-four lots of hogs, in which Kafir-corn, soy-beans or alfalfa were included in the rations in nearly every case; demonstrates the possibility of producing pork economically with feeds that can be produced even in the drier parts of the state.

BULLETIN 96. May, 1900. Farm Department. 20,000 copies.

Soil Inoculation for Soy-beans.—An account of a considerable number of experiments in the production of tubercles on the roots of soy-beans by inoculating with earth and with earth extracts. Some of these were in pots or small plats, others on a field scale. Drilling in the beans and with them inoculated soil by means of a fertilizer attachment was found to be the best means of inoculating the crop.

BULLETIN 97. May, 1900. Farm Department. 30,000 copies.

Skim-milk Calves.—A detailed account of highly successful efforts to raise calves on skim-milk, thus enabling the fresh milk to be used in butter-making without diminishing the value of the calves.

BULLETIN 98. May, 1900. Horticultural and Entomological Department. 20,000 copies.

Some Scale-insects upon Kansas Grasses.—Gives a brief account of the scale-insects in general, with a more extended popular description of the grass-inhabiting forms, now first recorded from Kansas, and for one important genus, now first recorded from the United States. This account is followed by a list of the known species from the United States, a list of Kansas species, with the grasses infested by them, and analytical tables and descriptions of new species. The paper is illustrated by six plates, containing twenty-five original figures.

Press Bulletins.

No. 46. September 25, 1899. Farm Department. 16,500 copies.
Soy-beans.

No. 47. October 24, 1899. Botanical Department. 2500 copies.
Awnless Brome-grass.

No. 48. October 31, 1899. General Department. 2500 copies.
The Kansas Experiment Station.

No. 49. November 7, 1899. Entomological Department. 2000 copies.
A Horn-fly Trap Experiment.

No. 50. November 14, 1899. Veterinary Department. 2000 copies.
Infectious Abortion in Cattle.

No. 51. November 28, 1899. Farm Department. 3000 copies.
Alfalfa in Eastern Kansas.

No. 52. December 1, 1899. Botanical Department. 2000 copies.
Some Nitrogenous Forage-plants.

No. 53. December 5, 1899. Chemical Department. 2000 copies.
Experiments with Sugar Beets in 1899 and 1900.

No. 54. December 26, 1899. Farm Department. 3000 copies.
Kafir-corn.

No. 55. January 2, 1900. Botanical Department. 2700 copies.
Plant Breeding by Bud Selection.

No. 56. January 9, 1900. Chemical Department. 3000 copies.
Digestion Experiments with Kafir-corn Stover and Kafir-corn Meal.

No. 57. January 23, 1900. Veterinary Department. 5500 copies.
Protective Inoculation against Blackleg in Cattle.

No. 58. January 30, 1900. Botanical Department. 4000 copies.
Questions about Forage-plants.

No. 59. February 6, 1900. Botanical Department. 3500 copies.
How to Test the Vitality of Garden Seeds.

No. 60. February 9, 1900. Farm Department. 3600 copies.
Gophers and Crab-grass versus Alfalfa.

No. 61. February 13, 1900. Horticultural Department. 2500 copies.
Salsify, or Oyster Plant.

No. 62. March 6, 1900. Farm Department. 4500 copies.
Tame Grasses for Kansas.

No. 63. March 6, 1900. Farm Department. 4500 copies.
Bromus Inermis.

No. 64. March 13, 1900. Botanical Department. 3500 copies.
Prevention of Grain Smuts.

No. 65. March 20, 1900. Entomological Department. 3500 copies.
Horn-fly Remedies.

No. 66. March 27, 1900. Horticultural Department. 3500 copies.
Causes of Failure in Spraying.

No. 67. April 24, 1900. Botanical Department. 3400 copies.
The Cultivated Catalpas.

No. 68. May 14, 1900. Entomological Department. 3400 copies.
The Buffalo Tree-hopper.

No. 69. June 12, 1900. Botanical Department. 3600 copies.
The Cultivated Millets.

No. 70. June 26, 1900. Botanical Department. 3600 copies.
Botanical Notes on Wheat and Spelt.

Work of the Departments.

Farm Department.—The chief line of work for the year in the Farm Department has been the continuation of the production and feeding of drought-resisting crops. In this line, seventy acres of soy-beans were raised, and part of the crop fed to dairy cows, calves, hogs, and fattening steers. Fifty acres of Kafir-corn were raised and fed.

Eighty acres of soy-beans and ten acres of cow-peas are now growing. Soy-beans have been sent to sixty-five counties in the state, and have been planted by 200 farmers. This will give a test of the value of soy-beans for every condition of soil and climate found in the state. Forty-six acres were inoculated in 1899 with the bacteria that form tubercles on the roots of soy-beans, and this inoculated soil for soy-beans has been sent to thirty-one farmers.

Eighty head of steers were fattened in an experiment to test methods of fattening steers without hogs following. Four hundred and thirty-five pigs were purchased for feeding experiments with drought-resisting crops. They were inoculated to prevent cholera, but 369 died. In January, two years' work was completed in fattening hogs with drought-resisting crops, 326 head having been fattened in these experiments. Eighty-one calves were fed during the year in the tests of skim milk, whey, hay tea, and whole milk.

Trials of soiling dairy cows were made with twenty-one cows.

As fast as work has been completed, bulletins have been issued giving the results of experiments, and details are unnecessary in this report.

The members of the farm force spent most of the fall of 1899 in attending farmers' institutes, attending 134 meetings. The meeting face to face with the farmers, and the personal presentation at these institutes of our experimental work, had the effect of inducing hundreds to test our methods who had not previously been influenced through bulletins, and created a large demand for the bulletins.

Botanical Department.—The experimental work of the Botanical Department of the Experiment Station includes work along the two lines, plant-breeding and forage-crops. In plant-breeding, an attempt is being made to improve our varieties of wheat, corn, soy-beans, Kafir-corn, and alfalfa. The experiments with wheat and corn have been carried on for three years. A large number of crosses were made in 1898 between the more desirable of the varieties of wheat grown in the plats that season. The results of the crosses, several hundred in unmber, were planted and carefully watched. The second generation of these crosses is under observation this season. During the present season a second series of crosses has been made, 850 heads in all, the object being to cross our best Kansas varieties—Turkey, Zimmerman, Red May, and Currel—with several promising Russian varieties sent to the Station by the United States department of agriculture. The results of these crosses will be reported upon later. Besides these crosses, ninety-eight varieties of wheat in plats were under observation, including samples received from successful wheat growers in the wheat belt of the state. The best heads of each variety were saved to continue the experiment the coming season. It is noticeable that the crosses show considerable superiority in general appearance over the neighboring varieties on the same soil. The crosses are being continued by carefully selected heads.

Several hundred crosses of corn were made in 1898 and the results have been under observation for two seasons. An attempt is being made to produce varieties richer in protein. With this end in view, the Chemical Department has determined by analysis the amount of protein in the crosses produced. During this season it is proposed to select and breed from those crosses which show the greatest proportion of protein. By successive selection and crossing, is is hoped that the per cent. of nitrogen can be materially increased. Three hundred and ninety-four samples of corn were planted this season in this series of experiments.

Soy-beans, Kafir-corn and alfalfa are being improved by seed selection, looking toward varieties showing better qualities than those we now possess. In addition to the grains mentioned, the department had on trial in plats eleven varieties of barley, two of emmer, two of rye, seven of broom-corn millet, and twelve of timothy. The last were received from Professor Hopkins, of West Virginia Experiment Station, and have already been bred for several generations. Some of these timothy plants are of superior merit and will be selected for future breeding.

To aid the work in forage-plants, the Botanical Department has established a grass garden, in which our native grasses, together with a large number of cultivated grasses and forage-plants, are grown in

plats. These plats are observed and noted, with a view of determining the adaptability of the different sorts to our conditions. Those varieties which give promise of success will be tried on a large scale by the Farm Department. An important series of experiments is under way to improve our valuable native grasses, such as bluestem and grama-grass, and produce varieties which will bear an abundance of fertile seed, thus enabling them to be grown from seed, as our common cultivated forage grasses. In the forage-plant exhibit, there are 212 kinds of native and cultivated grasses, and other forage-plants such as rape, vetches, spurry, Australian salt-bush, lupines, clovers, and various other legumes. Several of these samples were obtained of the United States department of agriculture for trial, being introduced from the old world.

As none of the work of the Botanical Department was sufficiently completed during the year to warrant a report, no bulletins were issued. A report on our cultivated forage plants is under way, however, and will be issued at an early date. Eight press bulletins were issued at intervals during the year.

Chemical Department.—The Chemical Department has completed a set of analyses of the soil at different depths from the land upon which wheat had been grown for eighteen consecutive years, and from an adjacent field which had produced a variety of crops. These will be published soon, and throw some interesting light on the question of soil exhaustion. The experiment in seed breeding of corn, in cooperation with the Botanical Department, has taken the greater part of the time and means of the department. Over 500 determinations of nitrogen in as many specimens of corn are in progress. These specimens are mainly crosses made by the Botanical Department, and the analyses will be used to guide the future work in selection and fixing of varieties. Owing to the destruction of the laboratory by fire May 31, 1900, these analyses have been materially delayed, and the botanical work will be somewhat hampered from this cause. The analyses incident to a number of digestion experiments have been made, and several more conducted. Unfortunately, the samples obtained in an experiment with sorghum hay and in a repetition of an experiment with prairie hay were lost in the fire. A bulletin will be issued soon giving an account of all of the digestion experiments completed. The department has continued to cooperate with the United States department of agriculture in the distribution of sugar-beet seed to farmers of the state requesting it, and has analyzed the beets produced last season. The results have been published in a bulletin. The present year, parties interested in the question have engaged a considerable number of farmers in the valley of the Kansas river to grow experimental plats under the direction of

an expert, the Station supplying them with the seed and analyzing the product. It is believed that this will be the best test yet made of the capacity of our state for sugar-beet production.

Horticultural and Entomological Department.—The following outline indicates the chief directions of the work in this department:

In the horticultural division, the collections of varieties have been maintained and extended; an orchard of several hundred selected seedlings of the sand plum (*Prunus watsoni*) has been set out on the sandy lands of the Kansas river, and a smaller collection, for comparison, in the clay loam of the College grounds; other native fruits, with a view to their study and improvement, have been grown from seed or propagated from trees of marked superiority in fruit, from various localities; extended observations were made upon fruiting varieties of the plum for early publication in bulletin form; an extended list, from foreign sources, of vegetables not recognized in home gardens, has been grown to learn their value here; the improvement of esculent roots by careful selection of plants for seed has been undertaken; cultural tests have been made in various lines.

In the division of entomology, important studies of the scale-insects inhabiting grasses, and extended collections of specimens from various localities have been made; the life-history of the grain-aphis has been studied; various proprietary insecticides have been given comparative trial; the destruction of the codling-moth has been the subject of careful reinvestigation; the protection of the cabbage from insects has been made a matter of extended experiment; and numerous minor subjects have been given attention and made a matter of record for future use.

Veterinary Department.—During the year closing June 30, 1900, the work of the Veterinary Department of the Experiment Station consisted in the continuation of work begun in previous years and of some new work. The manufacture and distribution of blackleg vaccine for protective inoculation was continued throughout the entire year. Two kinds of vaccine, double and single—the first requiring two, the latter one application—were manufactured and distributed.

It was found that the use of double vaccine, though attended with just double the time and trouble in its application, was safer and more permanent and reliable in results; also that for double vaccine shoulder inoculation was permissible, whereas, where single vaccine is used, tail inoculation is by far preferable, being safer and equally expedient.

Probably more than 100,000 cattle have been inoculated with blackleg vaccine manufactured in this department. The detailed results of these inoculations will be published in bulletin form early in 1901.

Besides experiments with blackleg protective inoculation, the department has done work along the following lines, viz.: Cockle-bur poisoning in young pigs, tuberculin diagnosis, swine-plague protective inoculation, phenol treatment as a preventive for infectious abortion in cattle, etc.

A short bulletin on swine-plague protective inoculation has been issued, and some favorable results have been obtained with phenol treatment for infectious abortion in cattle. A number of press bulletins have been issued by the department, and a correspondence which amounts to over 5000 letters per year has been carried on. These letters are chiefly answers to inquiries concerning diseases of farm animals, and include, of course, all inquiries relating to blackleg in cattle.

The department is now only moderately well equipped to do good and accurate scientific work. The time allotted the veterinarian for actual experimental work is also entirely too short. To do the best work, the Experiment Station veterinarian should be relieved from all college duties.

The present quarters of the Veterinary Department, the second floor of the old armory, are poor, and it is to be hoped that in the very near future better ones will be provided. An appropriation of $100,000 for building and equipment of a pathological laboratory would be one of the most paying investments the legislature of the state of Kansas could possibly make.

General Department.—During the past year the keeping of the financial records of the Station and the minutes of the meetings of Council has been in the hands of the secretary, Miss Clemons. The care of the mailing list and the general correspondence of the Station, and the oversight of the printing, binding and distribution of its publications, has been in charge of Professor Willard, as chairman of the Council or director. Certification to the correctness of vouchers has been made by President Nichols.

At the beginning of the fiscal year, the mailing list reached nearly 14,000 in numbers, a large proportion having been added within the six months preceding. These additions had been recorded in such a way that, with the older portions, the entire list was in such a form as to make it very expensive to use, and impossible to correct or to consult without an inordinate expenditure of time. A complete revision and the adoption of a permanent and flexible system was determined upon. The names of all who had been heard from within six months, in reference to bulletins, were checked on the list, and to the copy of Bulletin No. 89, sent to all others, a private mailing card was attached, which the recipient was requested to return with his

name and address, if he wished further bulletins sent to him. The names that had been checked were written on cards of the same size, and, with the private mailing cards returned, constituted the nucleus of the revised list. These cards are arranged alphabetically, as to states, post-offices, and individuals. As new names are added, each is placed upon a card, which is put in its proper alphabetical position.

The list is thus capable of indefinite expansion, ready consultation, and easy correction. The cards, in addition to the name, bear the date and show by what authority the name has been added; that is, whether at the request of the owner or that of some one else, and if the latter, whom. Additions to the list have been made in large numbers, but a special effort has been made to avoid anything like padding. Large lists are frequently sent in for entry, and the usual course has been to send to each one named a package of our bulletins treating on a variety of subjects, and with them a private mailing card, which can be returned with the name of the one who received it properly spelled and with his address. This then goes into the regular card list. Having the names thus sifted with considerable care, so as to insure sending the bulletins only to those who will appreciate them, it is believed that the list will not require frequent revision, but, whenever revision is necessary, it can be done intelligently and with discrimination by the aid of the date and other memoranda on the cards.

The mailing list, for convenience of use in the dispatch of the several classes of publications of the Station, and for certain advantages in referring to it, is divided into a number of distinct sections, and some of these are subdivided. A number of these groups of names have been added to the list by the Station Council with the expectation that, by sending the publications to them, many times as many more throughout the state would become acquainted with the work of the Station. The total number on our mailing list at the close of the fiscal year is over 17,000.

The card list is not used to mail from directly. The whole has been linotyped, and is held in that form, and as mailing sheets are required, proofs are taken off, which are used in addressing the envelopes by means of a mailing machine. As new names are added to the card list they are added to the linotype list also, each being put in its proper alphabetical place with the same facility as the cards are in the other lists. Names are dropped from the linotype list, when occasion requires, with equal ease. By this method we keep our mailing list revised to date. The expense of installing this system of handling the mailing list has not been very great, and it is maintained at a minimum cost.

It is proper to state in this connection that the actual mailing of publications to those on the printed list has been done in the College printing-office, under the immediate supervision of Supt. J. D. Rickman, to whose executive ability the Station is largely indebted for the promptness and accuracy with which the mailing of the year has been done.

The room formerly used by the College as a bookstore has been assigned to the Station for the storage of publications. We have here ample facilities for their convenient arrangement, and thus effect a considerable saving in the time required to mail bulletins in answer to the requests that are constantly received. After the bulletins have been sent to the regular list, the remainders are stored here, and of these 200 are reserved for future requirements in meeting the requests of libraries and officials for back publications. The others are available for use in answering inquiries, and are also sent to the new names added to the mailing list as long as there is a sufficient supply.

General Statement.

The influence and value of the Station have increased during the past year, as shown by the extent to which its publications have been copied, and the very appreciative letters that are received from the farmers of the state and elsewhere. Applications for our publications come from all parts of the world. Letters of inquiry upon the greatest variety of agricultural topics are received in large numbers, chiefly from our own state, but not infrequently from others, and even from foreign countries. This is doubtless in part due to the increasing knowledge of the experiment-station system of this country, and growing confidence in the value of results obtained through it.

One of the means by which the work of the Station has been brought to the favorable notice of the public has been through the farmers' institutes, which have been held in large numbers in nearly all parts of the state the past year. An appropriation was made by the legislature to cover the expenses of these institutes, but the chief draft for speakers has been upon the Experiment Station force. The Council believes that a limited attendance upon farmers' institutes is not only of benefit to the localities visited, but that the Station force, by coming in contact with the problems of the state by meeting its people, are able to do better work, and that in the future the demands of this important educational field should be met by an appropriation that will provide for an increase in the Station force.

Respectfully submitted.

E. R. Nichols. Paul Fischer.
J. T. Willard. H. M. Cottrell
A. S. Hitchcock. E. A. Popenoe.

THE STATION PUBLICATIONS,
to June 30, 1900.

ANNUAL REPORTS.

*First Annual Report, 1888.**

Financial statements, report of the Council, and reports of departments, including the following articles: Waste of Manure in Summering Manures in the Yard. Experiments in the Corn Field. Experiments with Wheat, including Bulletin No. 4. Forage Crops. The Milk and Butter Product as Influenced by Feeding. The Pressure of Ensilage on the Walls of the Silo. Relation of Rainfall to the Corn Crop. Shrinkage of Hay in the Mow. A Comparison of Varieties of Sorghum, including part of Bulletin No. 5. A Test of the Keeping Qualities of Sorghum. An Examination of Individual Stalks of Sorghum, with a view to Improving the Plant. A Trial of Fertilizers on Sorghum. A New Method of Milk Analysis for the Use of Dairymen. Spraying in the Apple Orchard. Observations upon Injurious Insects, including Bulletin No. 3. Trials of Varieties of Potatoes. Trials of Varieties of Peas. Trials of Varieties of Tomatoes. Sorghum Blight, including part of Bulletin No. 5. Hackberry Knot. Experiments in Fertilization of Varieties of Corn. Germination of Weed Seeds. The Fungous Parasites of Weeds.

*Second Annual Report, 1889.**

Financial statements, report of the Council, and reports of departments, including the following articles: Experiments with Corn, Wheat and Forage Crops, including Bulleting No. 7. Silos and Silage, including Bulletin No. 6. Pig-feeding Experiment, including Bulletin No. 9. Pigs from Mature and Immature Parents. Work upon Sorghum. Analysis of Feeding Stuffs. Composition of Corn at Different Stages of Growth. Ammonia and Nitric Acid in Atmospheric Waters. Comparative Trials of Garden Beans, of Peas, of Potatoes, of Tomatoes. Some Insects Injurious to the Bean. Loose Smuts of Cereals, including Bulletin No. 8. Crossing Varieties of Corn, First Year. Receptivity of Corn Silk.

Third Annual Report, 1890.

Financial statements, and a report of the Council, including outlines of Bulletins 10 to 19, with index, and a summary of work in progress.

Fourth Annual Report, 1891.

Financial statements, and a report of the Council, including outlines of Bulletins 20 to 32, with index, and summary of work in progress.

Fifth Annual Report, 1892.

Financial statements, and a report of the Council, including outlines of Bulletins 33 to 37, with index, and summary of work in progress.

Sixth Annual Report, 1893.

Financial statements, and a report of the Council, including an account of work in progress, outlines of Bulletins 38 to 45, a meteorological summary for thirty-six years, and an index.

*Out of print. The annual reports for 1888 and 1889 contain the subject-matter of Bulletins Nos. 3 to 9, inclusive.

Seventh Annual Report, 1894.

Financial statements, and a report of the Council, containing outlines of Bulletins 46 to 48, statements concerning irrigation experiments and other work in progress, and an index.

Eighth Annual Report, 1895.

Financial statements, and a report of the Council, containing outlines of Bulletins 49 to 56, a summary upon irrigation and other work in progress, and an index.

Ninth Annual Report, 1896.

Financial statements, and a report of the Council, containing outlines of Bulletins 57 to 64, a summary concerning irrigation and other work in progress, and an index.

Tenth Annual Report (January 1 to June 30), 1897.

Financial statements for the fiscal year, and a report of the Council for six months, including outlines of Bulletins 65 to 74, summary of work in progress, and an index to the report and Bulletins 65 to 75.

Eleventh Annual Report, 1897-'98.

Financial statements, and a report of the Council, containing outlines of Bulletins 76 to 80, and a summary of the work of the year and in progress.

Twelfth Annual Report, 1898-'99.

Financial statements, and a report of the Council, including outlines of Bulletins 81 to 89, a list of Press Bulletins 1 to 45, issued during the year, a summary of work in progress, and an index.

Thirteenth Annual Report, 1899-1900.

Financial statements, and a report of the Council which includes outlines of Bulletins 90 to 98, a list of Press Bulletins 46 to 70, issued during the year, summary reports of the work of the departments, and an index.

BULLETINS.

*No. 1..April, 1888.....Organization, Equipment, and Aims.
*No. 2..April, 1888.....Experience with Cultivated Grasses and Clovers.
*No. 3..June, 1888.....Life-history of Two Orchard Pests.
*No. 4..September, 1888.....Experiments with Wheat.
*No. 5..December, 1888.....Sorghum, and Sorghum Blight.
*No. 6..July, 1889.....Silos and Ensilage.
*No. 7..July, 1889.....Experiments with Wheat.
*No. 8..October, 1889.....Preliminary Report on Smut in Oats.
*No. 9..December, 1889.....Experiment in Pig Feeding.
*No. 10..May, 1890.....Notes on Conifers for Kansas Planters.
No. 11..July, 1890.....Experiments with Wheat.
No. 12..August, 1890.....Preliminary Experiments with Fungicides for Stinking Smut of Wheat.
No. 13..August, 1890.....Experiments with Oats.
No. 14..December, 1890.....Winter Protection of Peach Trees, and Notes on Grapes.
No. 15..December, 1890.....Additional Experiments and Observations on Oat Smut.

*Out of print. (The annual reports for 1888 and 1889 contain the subject-matter of Bulletins Nos. 3 to 9, inclusive.)

No. 16..December, 1890 .....Experiments with Sorghum and Sugar Beets.
No. 17..December, 1890 .....Crossed Varieties of Corn, Second and Third Years.
No. 18..December, 1890 .....Experiments with Forage Plants.
No. 19..December, 1890 .....Germination of Weeviled Peas. Garden Notes on Potatoes, Beans, and Cabbage.
*No. 20..July, 1891 .....Wheat.
No. 21..August, 1891.....Stinking Smut of Wheat.
*No. 22..August, 1891.....Smut of Oats; Smut and Rust of Wheat.
No. 23..August, 1891.....Smut of Sorghum and Corn.
No. 24..September, 1891.....Staggers of Horses.
*No. 25..December, 1891 .....Sorghum for Sugar.
No. 26..December, 1891 .....Varieties of the Strawberry.
No. 27..December, 1891 .....Crossed Varieties of Corn.
No. 28..December, 1891 .....The Experimental Vineyard.
No. 29..December, 1891 .....Oats.
*No. 30..December, 1891 .....Corn.
No. 31..December, 1891 .....Sugar Beets.
*No. 32..December, 1891 .....Feeding Stuffs, and the Development of Grain Crops. Soy Beans.
*No. 33..August, 1892.....Experiment with Wheat.
*No. 34..September, 1892.....Experiments in Feeding Steers.
*No. 35..December, 1892 .....*Actinomycosis bovis*, or "Lumpy Jaw" of Cattle. Some Observations upon Loco.
*No. 36..December, 1892 .....Experiments with Sorghum and with Sugar Beets.
No. 37..December, 1892 .....Experiments in Potato Culture.
No. 38..March, 1893.....Preliminary Report on Rusts of Grain.
No. 39..August, 1893.....Experiments in Feeding Steers, II.
No. 40..August, 1893.....Experiments in Wheat.
No. 41..December, 1893 .....Effect of Fungicides upon the Germination of Corn.
No. 42..December, 1893 .....Experiment with Oats.
No. 43..December, 1893 .....Experiments with Sorghum and Sugar Beets.
No. 44..December, 1893 .....Further Study of Native Grapes.
No. 45..December, 1893 .....Experiments with Corn.
No. 46..May, 1894 .....Rusts of Grain, II.
No. 47..August, 1894.....Experiments with Wheat. Experiments in Feeding Steers, III.
No. 48..December, 1894.....Six Years' Experince with Ensilage. Some Forage Plants. Renovating a Prairie Pasture.
No. 49..May, 1895.....Cattle Poisoning by Potassium Nitrate. Mastitis.
No. 50..June, 1895 .....Kansas Weeds, I—Seedlings.
No. 51..June, 1895 .....Steer Feeding, IV—A Comparison between Pure-bred Shorthorns and Scrubs.
No. 52..September, 1895.....Kansas Weeds—Preliminary Circular on Distribution.
No. 53..October, 1895 .....Pig-feeding Experiments with Corn, Wheat, Kafir-corn, and Cottonseed.
No. 54..December, 1895.....Experiments with Oats.
No. 55..December, 1895.....Small Fruits by Irrigation. Culture of Strawberries.
No. 56..December, 1895.....Experiments with Corn. Experiments with Kafir-corn.

*Out of print.

No. 57..June, 1896.....Kansas Weeds, III—Descriptive List.
No. 58..June, 1896.....Cornstalk Disease of Cattle.
No. 59..August, 1896.....Experiments with Wheat.
No. 60..September, 1896.....Steer-feeding Experiments, Series V.
No. 61..November, 1896.....Kafir-corn, Corn and Soy-bean Meal for Pigs. Kafir-corn and Corn-meal for Cattle.
No. 62..December, 1896.....Corn-smut.
No. 63..December, 1896.....Experiments with Oats.
No. 64..March, 1897.....Experiments with Corn.
No. 65..May, 1897.....Grafting the Apple.
No. 66..June, 1897.....Kansas Weeds, IV—Fruits and Seeds.
No. 67..June, 1897.....Steer Feeding, VI.
No. 68..June, 1897.....Soil Moisture.
No. 69..June, 1897.....Some Diseases of Cattle.
No. 70..July, 1897.....Vegetable Growing.
No. 71..July, 1897.....Experiments with Wheat.
No. 72..July, 1897.....Growth of Young Stock.
No. 73..July, 1897.....Miscellaneous Fruit Notes.
No. 74..July, 1897.....Experiments with Oats.
No. 75..August, 1897.....Root Development of Forage Plants.
No. 76..February, 1898.....Kansas Weeds, V—Vegetative Propagation.
No. 77..March, 1898.....Some Insects Injurious to the Orchard.
*No. 78..April, 1898.....Sugar Beets.
No. 79..April, 1898.....Bovine Tuberculosis.
No. 80..June, 1898.....Kansas Weeds, VI—Distribution and Other Notes.
No. 81..September, 1898.....Feed and Care of the Dairy Cow.
*No. 82..January, 1899.....The Potato-stalk Weevil.
No. 83..April, 1899.....Sugar Beets.
No. 84..April, 1899.....Cold Storage for Fruit.
*No. 85..April, 1899.....The Growth of Alfalfa in Kansas.
*No. 86..June, 1899.....Press Bulletins Nos. 1 to 34.
No. 87..April, 1899.....Native Agricultural Grasses of Kansas.
*No. 88..May, 1899.....Keeping Milk in Summer.
No. 89..June, 1899.....Soil Moisture.
No. 90..January, 1900.....Alfalfa in Eastern Kansas.
No. 91..February, 1900.....Swine-plague.
No. 92..March, 1900.....A New Drought-resisting Crop—Soy-beans.
No. 93..March, 1900.....Kafir-corn.
No. 94..April, 1900.....Sugar Beets, 1899. The Station Publications. Partial Index to Station Publications.
No. 95..April, 1900.....Fattening Hogs with Drought-resisting Crops.
No. 96..May, 1900.....Soil Inoculation for Soy-beans.
No. 97..May, 1900.....Skim-milk Calves.
No. 98..May, 1900.....Some Scale-insects upon Kansas Grasses.

Press Bulletins.

No. 1..August 2, 1898.....Wheat Experiments.
*No. 2..August 9, 1898.....Keeping Milk in Summer.
No. 3..August 16, 1898.....The Fringed-wing Apple-bud Moth.
No. 4..August 23, 1898.....Soil Moisture and Soil Stirring.
*No. 5..August 30, 1898.....Blackleg.
No. 6..September 6, 1898...The Sand Plum.
*No. 7..September 13, 1898..Kafir-corn for Fattening Pigs.
No. 8..September 20, 1898..Some Reasons why Fruit does not Set.

* Out of print.

*No. 9..September 27, 1898..The Peach Twig-borer.
*No. 10..October 4, 1898.....Fall Preparation for Alfalfa Seeding.
*No. 11..October 18, 1898.....Celery.
No. 12..October 26, 1898.....The Balanced Ration.
No. 13..November 1, 1898....Seed Breeding.
No. 14..November 8, 1898....The Fruit-tree Bark-beetle.
No. 15..November 15, 1898...Kansas Sugar Beets for 1898.
*No. 16..November 29, 1898...*Actinomycosis* (Lump-jaw, Big-jaw).
No. 17..December 1, 1898....Hardy Ornamental Shrubs.
No. 18..December 13, 1898...Notes on Weeds.
No. 19..December 20, 1898...The Potato-stalk Weevil.
No. 20..December 27, 1898...Possibilities of Corn Improvement.
No. 21..January 10, 1899 ....Winter Protection of Peach Buds.
No. 22..January 24, 1899 ....Grazing Grasses of Western Kansas.
No. 23..January 31, 1899 ....The Spring Canker-worm.
No. 24..February 7, 1899 ....A New Crop for Kansas Farmers (Soy-beans).
No. 25..February 14, 1899 ...Alfalfa Hay for Fattening Hogs.
*No. 26..February 14, 1899 ...*Tænia fimbriata* (Fringed Tapeworm).
*No. 27..February 20, 1899 ...Sugar Beet Experiments for 1899.
No. 28..February 21, 1899 ...Treatment of Winter-injured Trees.
No. 29..February 20, 1899 ...Milking Scrub Cows.
*No. 30..February 24, 1899 ...Lice on Animals.
No. 31..March 6, 1899.....Potato Scab.
*No. 32..March 9, 1899.....Blackleg (A).
*No. 33..March 14, 1899.....Blackleg (B).
No. 34..April 7, 1899.....Get Ready for the Drought.
*No. 35..April 5, 1899.....Dysentery in Calves and Other Young Animals.
No. 36..May 3, 1899.....Experiments with Swine-plague or Hog-cholera.
*No. 37..May 8, 1899.....Kafir-corn, Alfalfa Hay and Soy-beans for Pork.
No. 38..May 12, 1899.....What is a Digestion Experiment?
No. 39..May 22, 1899.....Skim-milk Calves.
*No. 40..May 27, 1899.....Orchard Cultivation.
No. 41..June 13, 1899.....Digestion Experiment with Alfalfa Hay.
*No. 42..June 20, 1899.....To Rid the House of Flies.
No. 43..June 17, 1899.....Selection of Seed Wheat.
No. 44..June 17, 1899.....The Profitable Strawberry Bed.
No. 45..June 27, 1899.....Early Plowing and Moisture Conservation.
No. 46..September 25, 1899..Soy Beans.
No. 47..October 24, 1899.....Awnless Brome-grass.
No. 48..October 31, 1899.....The Kansas Experiment Station.
No. 49..November 7, 1899....A Horn-fly Trap Experiment.
No. 50..November 14, 1899...Infectious Abortion in Cattle.
*No. 51..November 28, 1899...Alfalfa in Eastern Kansas.
No. 52..December 1, 1899....Some Nitrogenous Forage-plants.
No. 53..December 5, 1899....Experiments with Sugar Beets in 1899 and 1900.
No. 54..December 26, 1899...Kafir-corn.
*No. 55..January 2, 1900 .....Plant Breeding by Bud Selection.
No. 56..January 9, 1900 .....Digestion Experiments with Kafir-corn Stover and Kafir-corn Meal.
No. 57..January 23, 1900 ....Protective Inoculation against Blackleg in Cattle.
No. 58..January 30, 1900 ....Questions about Forage-plants.
No. 59..February 6, 1900 ....How to Test the Vitality of Garden Seeds.
No. 60..February 9, 1900 ....Gophers and Crab-grass *versus* Alfalfa.
No. 61..February 13, 1900...Salsify, or Oyster Plant.
No. 62..March 6, 1900.....Tame Grasses for Kansas.
No. 63..March 6, 1900.....*Bromus inermis.*
No. 64..March 13, 1900.....Prevention of Grain Smuts.
No. 65..March 20, 1900.....Horn-fly Remedies.
No. 66..March 27, 1900.....Causes of Failure in Spraying.
No. 67..April 24, 1900 .....The Cultivated Catalpas.
No. 68..May 14, 1900.....The Buffalo Tree-hopper.
No. 69..June 12, 1900.....The Cultivated Millets.
No. 70..June 26, 1900.....Botanical Notes on Wheat and Spelt.

*Out of print.

EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN No. 90—JANUARY 1900.

FARM DEPARTMENT.

H. M. COTTRELL, M. S., Agriculturist.
D. H. OTIS, M. S., Assistant in Dairying.
J. G. HANEY, B. S., Assistant in Field and Feeding Experiments.

ALFALFA IN EASTERN KANSAS.

WE have been investigating the growth of alfalfa in eastern Kansas for more than two years. We have held as many as five farmers' institutes in a single county without seeing one field of alfalfa. We met a farmer who had lived thirty years in Labette county who had never seen an alfalfa plant growing, and there is comparatively little alfalfa grown in the eastern third of the state.

As alfalfa is absolutely essential to the cheapest production of beef, pork, and milk, and the rapid growth of young farm animals, it is evident that farmers without it are at a great disadvantage. Our work in fattening hogs shows its value. One lot of hogs were fed all the grain they would eat, and another lot all the grain and all the alfalfa hay they would eat. The hogs having the alfalfa hay ate more grain and gained more pounds of pork for each bushel of grain consumed, showing a gain of 868 pounds of pork per ton of alfalfa hay. Hogs on alfalfa pasture showed a gain of 776 pounds per acre of pasture.

We find that alfalfa hay and corn or Kafir-corn makes the cheapest combination of feeds for milk production, securing a good yield of milk and of butter-fat at the least cost, with butter of good quality in regard to firmness. With skim-milk, Kafir-corn, grain and alfalfa hay we have been able to make calves gain nearly two pounds per day

from birth to six months of age, a gain equal to that made by calves sucking their dams.

This Station has not had sufficient money to test the value of alfalfa for fattening steers. Feeders report that, in fattening steers with corn, when hay, fodder or sorghum is used for roughness, the steers gain from one and one-half to two pounds per day each. When alfalfa hay is the rough feed, fattening steers gain three and one-half to five pounds per day each. Alfalfa is our best soil enricher, bringing up plant-food to the surface soil from greater depths than any other crop plant grown in Kansas. It seems imperative. then, that eastern Kansas farmers should grow alfalfa, if possible, as they need it both for feed and for fertilizer.

Most trials of alfalfa in eastern Kansas have been failures, but we have found alfalfa grown successfully under almost every condition of soil to be found in the eastern part of the state, and we believe that a large portion of eastern Kansas, from Nebraska to Indian territory, is a natural alfalfa country. Alfalfa will not grow on wet land nor where rock comes near the surface. It is easiest grown where the subsoil is rich and porous, but good crops have been harvested many years in succession on land underlaid with as tough and hard subsoils as there are in the state. A successful alfalfa grower of wide experience recently said that any land which will produce good corn regularly and on which cottonwood trees do well is good alfalfa land. This is a fairly safe guide.

The failures in alfalfa growing in eastern Kansas have come where methods suitable for western Kansas have been adopted, and successes have followed where entirely different methods have been used. In eastern Kansas, owing to many years of cultivation and a good rainfall, the land is weedy. The usual experience is as follows: Ground thoroughly prepared in the spring, seed immediately put in, a good stand, and rapid, early growth; in September, a field with some alfalfa and a perfect stand of foxtail; next spring, no alfalfa or only half a stand. This experience is usually repeated two or three times, and alfalfa, not paying, is dropped.

As a rule, we have found that the successful alfalfa growers in eastern Kansas have started to prepare the ground a year before sowing the seed. They plant the land intended for alfalfa in corn or some other cultivated crop. They cultivate thoroughly and keep the land free from weeds. The following spring oats, or some other crop that can be taken off early, is put in, and as soon as the crop is harvested the ground is immediately plowed and thoroughly harrowed. It is then harrowed or cultivated about once in ten days until the fall rains come. This harrowing has a double effect: it keeps a constant suc-

cession of weeds starting, only to be destroyed, and it causes a rapid formation in the soil of the nitrogen compounds essential to the growth of the young alfalfa plants. Late in August or early in September, as soon as the ground has been well wet, the alfalfa is sown. It may be put in broadcast. A better way is to mix equal quantities, by measure, of bran and alfalfa seed, drill and cross-drill, sowing half the seed each way. If the season is favorable, the growth of the alfalfa will be good through the fall, and a good hay crop will be secured the following year. If the ground does not get thoroughly wet in the fall do not sow, but sow the following spring, and after the alfalfa gets four to six inches high, cut every ten days or two weeks, whether the weeds are bad or not, with a mower set as high as possible. Mowing, to alfalfa, when just started, is as valuable as cultivation to corn. It makes the plant more vigorous.

A crop of soy-beans raised for seed is better than a grain crop to raise just before seeding to alfalfa. The beans, if planted early, can be taken off in time to sow the alfalfa, and the alfalfa can be put in without plowing the ground.

Alfalfa does not want a nurse crop. It does not want to be put in loose, freshly plowed ground. The ground should become settled after plowing, and just the surface made loose before planting. Time after time we have heard farmers report at farmers' institutes that they plowed their ground deep, harrowed it thoroughly, immediately sowed the alfalfa, and it was a failure. Deep plowing and thorough harrowing are needed, but let the ground settle before seeding. Alfalfa should not be pastured for the first two years.

We have found many farmers who have been unsuccessful with alfalfa who have cut it for hay just as they would clover—after the field had passed full bloom. In most cases this alone is sufficient to destroy the plants. Alfalfa should be cut in early full bloom, and it is better to make the first cutting in the spring before two-thirds of the plants come in bloom. On the College farm, in a dry season, we have seen the first crop when cut at this stage followed by a heavier second crop and a good third crop, while that left to be cut like clover was not ready much before the second cutting of the early cut, and yielded no hay after the first cutting. In rainy seasons we have sometimes cut the first cutting early when we knew it would be spoiled by rain, because if we waited we would have a poor second cutting, and probably no third cutting at all. Cut alfalfa early.

With poor stands on old alfalfa fields it will pay to disc thoroughly as early in the spring as the ground can be worked. We have secured good yields from old fields of alfalfa having less than half a stand by taking a sharp disc harrow, well weighted, and harrowing and cross-

harrowing as deeply as the machine will run. The fields looked as if all the alfalfa had been destroyed, but good yields followed. At this Station we disc alfalfa in March. A few farmers have reported alfalfa killed by discing in the fall.

We believe that it will pay three-fourths of the farmers of eastern Kansas to make a trial of alfalfa on the lines indicated in this article. Five acres is sufficient for the first trial; less is not practicable. Follow suggestions carefully; watch the progress closely. The results in most cases will be satisfactory; and where they are not, a farmer with good judgment, with this close watching, can develop modifications of these methods that will succeed on his farm.

EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN No. 91—FEBRUARY 1900.

VETERINARY DEPARTMENT.

PAUL FISCHER, B. Agr., M. V. D., Veterinarian.
A. T. KINSLEY, B. S., Assistant in Veterinary Department.

SWINE-PLAGUE.

FOR some time the Veterinary Department of the Kansas State Agricultural College Experiment Station has been conducting experiments in protective inoculation against swine-plague. The material used for the inoculations was a pure attenuated culture of *Bacillus suis* (the swine-plague germ) prepared and furnished by Prof. H. J. Detmers, of Columbus, Ohio. Although our experiments may thus far be considered successful, they have not been sufficiently extensive to warrant the publication of results that to many would, to say the least, be misleading. Instead, therefore, of devoting these pages to recording our successes, we shall venture in the opposite direction, and record what was, if not a failure, at least an experience showing an apparent drawback to the successful introduction of protective inoculation as a solution to the question of controlling the worst swine disease in America.

Protective inoculation against swine-plague is based on the same principles on which rests successful protective inoculation against smallpox, blackleg, or any other infectious disease. Common observation has shown that when men or animals have recovered from diseases like smallpox, anthrax, blackleg, Asiatic cholera, etc., they are rarely attacked a second time. This condition of the animal body

which enables it to resist disease is called immunity. The degree of immunity thus produced, within certain limits, is the same whether the first attack of the disease was a severe or mild one, natural or artificial. We make use of this knowledge to bring about immunity by producing an artificial but mild attack of the disease in question. This is done by inoculating the animal with a culture of the specific disease germs that have previously been partially robbed of their virulence. The virulence of disease germs is reduced by submitting them to various unfavorable conditions of growth, such as high or low temperatures, artificial food media, uncongenial surroundings, etc., etc., but which need not be further discussed at this place.

The characteristic symptoms of swine-plague are due, in part at least, to the production, in the animal tissues, by swine-plague germs, of poisonous substances known as toxines. When virulent cultures are introduced into the body, the toxines produced are so abundant and effective that they overcome the tissue cells, and severe disease or death follows. When attenuated cultures are thus introduced the toxines formed are milder in their action, affect the tissue cells gradually, and give the latter time to overcome the injurious effects of the former. When the cells of the body have once been exposed and have offered successful resistance to an attack of disease germs, they are prepared to resist a second, more violent, attack by the same species of germ with the same or even greater success. The individual cells of the body have the same power of becoming inured to hardships, injurious influences and uncongenial surroundings as has the body as a whole, which, in fact, may be regarded as a large, organized mass of cells.

To repeat, the action, in a general way, of attenuated cultures of germs, when these are used for protective inoculation, is precisely the same as the action of virulent cultures of germs when they produce a fatal disease. The only difference between the two is one of degree.

Now, one of the greatest difficulties encountered in our experiments with protective inoculation is to convince farmers that it is useless, or worse than useless, to inoculate sick or exposed hogs with an attenuated culture of swine-plague germs. This may be illustrated thus: Suppose an animal were poisoned by drinking a great quantity of some strong fermented liquor, like brandy, which contains about fifty per cent. of alcohol: would it not seem ridiculous to attempt to save this animal's life by beginning now to accustom it to the effects of alcohol by feeding it additional but diluted potions of the same beverage? Attempting to save an infected animal by administering dilute or attenuated doses of the poisons (toxines) that are the actual cause of the disease is an analogous case. But, on the other hand, by

feeding the diluted poisons before the full-strength poisons have been administered, the animal organism will gradually accustom itself to stronger and stronger doses, until full-strength doses can be administered without harm. There are, of course, limits to all these assertions, but within these limits the facts will bear out the statements. On these principles protective inoculation rests, and this once fully understood, there will be no danger of confounding *protective inoculation* with curative treatment. The average farmer is unwilling to go to any reasonable expense in order to protect himself against a danger not yet in sight, but when it is too late he is too often willing to go to the opposite extreme and permit himself to be imposed upon by the very worst kind of pretenders—the venders of patent medicines.

As already stated, our great difficulty lies in trying to induce farmers to inoculate their pigs *in time*, before they have swine-plague or cholera, and before their neighbors' pigs across the road begin dying of this disease (or diseases?).

When healthy pigs (pigs free from disease or from infection) have been inoculated in our experiments, no deaths from swine-plague have been observed to follow. There is one exception to this statement, but all details of this have not yet been worked out, and hence it may be premature to consider it here. However, this system of preventive treatment is not supposed to be absolutely infallible.

It may, however, be proper to state here that the Veterinary Department has always been opposed to the inoculation of hogs whose history was such that it was practically impossible to know or find out whether or not the herd in question was free from swine-plague, or from an exposure to this disease. We further believe that no herd of swine that has been bought up from all over the country, so to speak, and then shipped by rail and unloaded in public stock-yards, can in any manner whatever lay claim to a clear bill of health. Even granting that the pigs were healthy when bought, the chances for infection during transportation are altogether too great to be left out of the question.

The most interesting incident in all our experiments, for the present, perhaps, is the inoculation of what was known as the College herd of hogs. This herd comprised 434 pigs, ranging in age from about three to five months. These pigs were bought for experimental feeding by the Farm Department in two distinct lots and at two different dates. Each lot was composed of a mixture of shoats—such as farmers were willing to sell. Lot I contained 114 pigs, and arrived at the College farm in four different lots on four different days (June 20, 21, 22, 23). These pigs were observed for nearly two weeks in order to detect symptoms of swine-plague, if such were present. In the

apparent entire absence of positive symptoms of this disease, and the statement of the purchaser that the pigs came from a region free from swine-plague, the herd was considered free from this disease, in as far as it was possible for us to determine at that time, and was inoculated July 11, 1899.

At this time we had not yet discovered the value of the fact that the temperatures of swine can be used to such great advantage in diagnosing swine-plague. In our later work this has been a great aid to us, and thus far has never failed to throw light on doubtful cases.

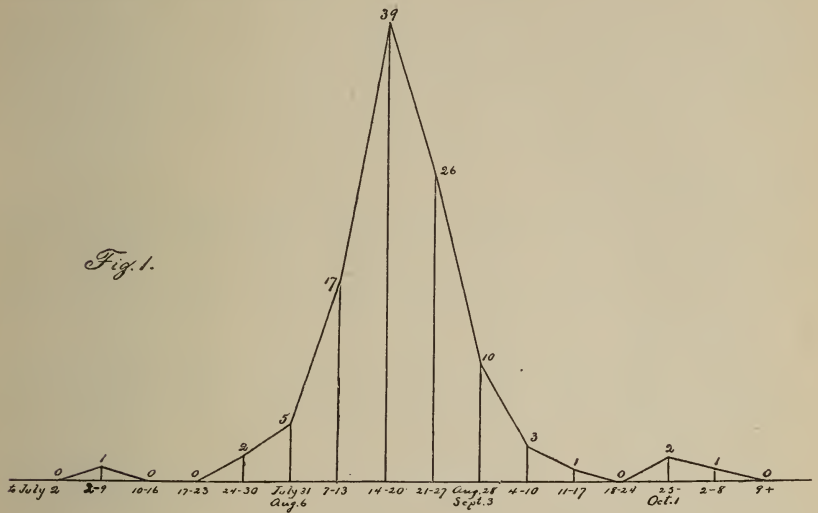
As it was, the very last pig inoculated turned out to be an exceedingly scrubby-looking one, greatly emaciated, rough coat of hair, no appetite, and feverish. This pig was inoculated but isolated. The attendant failed previously to call our attention to the condition of this pig, as he had been instructed to do. After a few days this pig's appetite returned; it seemed to be well, and, without orders to do so, was turned out among the rest by the attendant. Thus, unfortunately, we lost sight of this individual pig.

Now, as to lot II. This comprised 320 pigs, of the same origin as lot I, but a better-looking lot. They were received at the College August 4, placed in new and isolated pens built for this purpose, observed until August 11, and then inoculated like lot I. These pigs were observed for seven days, in order to detect, if possible, symptoms indicating the possible presence of swine-plague. During this time the men in charge had strict orders to keep the pigs isolated, so that, should they prove to be infected, the other lots would not suffer. Similarly, the men in charge were instructed to guard them carefully for ten or twelve days after inoculation, the period required to produce immunity, and thus not expose them to infection before immunity had been produced. Although the Veterinary Department did not have charge of this work, we must assume that all particulars were carefully attended to. With these statements, and others that will follow, the fact that all but fifty-six pigs out of lot II died of swine-plague during the next fifty-three days can be explained in one way only, and that is, that the pigs were infected with the germs of the disease when they arrived at the College farm. So much for the history of the two lots up to the time they were inoculated.

July 24, thirteen days after the inoculation of lot I, a dead pig from that lot was brought to the Veterinary Department for examination. On the following day another pig was brought in, and six days later another. The disease was pronounced swine-plague, and following will be found a diagram illustrating the rate at which the pigs died. The figures given are for successive weeks, beginning with death of first pig, July 2, and ending with death of last pig that died of swine-

plague, October 8, 100 days from time of first death. Only seven pigs out of a lot of 114 survived.

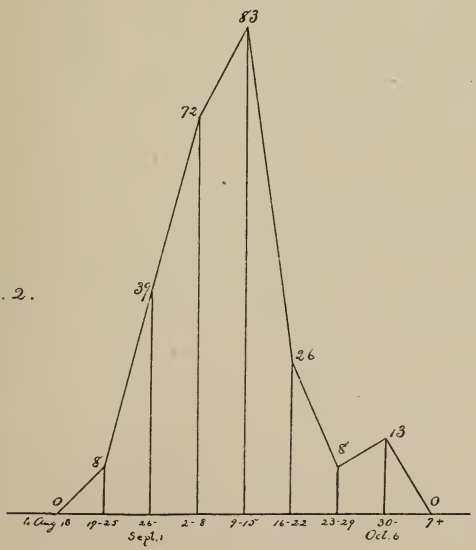
Fig. 1.



NOTE.—The death that occurred July 2 was not reported until after the pigs were inoculated, and hence could not be investigated. The probability is that it was due to swine-plague.

August 19, eight days after inoculation, the first pig in lot II died with swine-plague, and then the mortality rate in that lot steadily increased until the greater part of the herd was lost. The rate at which these died is indicated by the following diagram:

Fig. 2.



At the end of forty-five days after the first death in lot II, which originally contained 320 pigs, fifty-six were left. These are still living and doing well, December 30, 1899.

It will be noticed that the first pig in lot I died on July 2, 1899, about ten days after the arrival of the pigs on the College grounds. The next pig died July 24, more than four weeks after the arrival of the lot at the College grounds, but just twenty-two days after the death of the first pig.

In lot II, the first death occurred fifteen days after their arrival on the College grounds. In lot I, the pigs began dying about four weeks after their arrival.

This in brief, is a history of the swine-plague epidemic that visited the College herd.

As soon as the disease was recognized every possible precaution, in the way of proper use of disinfectants, quarantining, etc., that was possible on premises where a large number of students were employed for help, was taken. This did not prevent certain experiments with internal remedies on selected lots, all of which, it may be needless to state, proved ineffective. Absence from College on other duties and on a short vacation, which latter, however, was immediately interrupted upon hearing of the deaths taking place in the herds, made impossible other observations that would have been of value.

After eight pigs out of lot II (containing 320 pigs) had died, it was suggested that possibly the inoculation of the hogs with Detmers' virus was the direct cause of the outbreak of the disease. To obtain light on this question, ten average-looking hogs from a health oint of view were selected from lot II: we will designate these lot II[1]. These pigs averaged three to four months in age and 50 to 100 pounds in weight. The dose of virus that each received when inoculated with the rest of the herd was 0.1 c.c. for each month of the pig's age, and in addition, 0.05 c.c. for each individual pig. Thus the dose for a four-months-old pig was 0.45 c.c. This was varied a little according to the weight of the animal.

These pigs were carefully examined; most of them had excellent appetites, were in good spirits and of fairly healthy appearance. Their temperatures ranged from 104.4° F. to 109.0° F., or as follows:

No. 1	107.5°	No. 6	104.4°
No. 2	106.9°	No. 7	109.0°
No. 3	106.0°	No. 8	108.4°
No. 4	108.4°	No. 9	108.4°
No. 5	107.2°	No. 10	108.1°

The normal temperature of a pig ranges from about 102° F. to about 105° F., varying with age, sex, surrounding temperature, time of day, and other conditions.

No. 6, as will be noted, was the only pig with a normal temperature. All others had a high fever. Every one of these ten pigs then received 5 c.c. (ten full doses) of a check flask of *Bacillus suis* culture, injected subcutaneously on the inner side of the left thigh. The effect that this inoculation had can be best shown by examining the temperature records which follow:

	August.						September.			
No.	26	27	28	29	30	31	1	2	3	
1*.....	107.5	108.0	108.0	107.6	108.8	107.4	108.3	106.3	107.0	died.
2*.....	106.9	106.6	106.0	108.3	108.8	108.2	108.2	108.1	107.1	
3*.....	106.0	107.3	106.0	106.8	107.4	107.2	108.7	107.2	108.6	
4*.....	108.4	109.0	107.8	108.6	107.9	108.2	108.2	107.3	107.8	
5*.....	107.2	106.4	105.6	103.1	103.4	105.5	105.4	105.3	106.0	
6.....	104.4	106.6	104.4	104.8	105.0	103.8	103.4	103.8	103.8	
7*.....	109.0	109.4	109.0	109.4	108.6	108.5	108.5	109.1	109.0	
8*.....	108.4	108.6	109.4	107.3	108.4	108.1	108.8	107.8	109.3	
9*.....	108.4	109.4	108.2	108.4	108.6	107.8	107.5	106.5	108.4	
10*.....	108.1	109.2	109.0	108.5	107.4	108.3	106.9	108.8	109.1	

	September.									
No.	4	5	6	7	8	9	10	11	12	13
2*.....	108.3	108.1	109.6	died.						
3*.....	107.8	107.4	108.0	106.2	105.5	104.7	104.9	106.1	104.7	died.
4*.....	107.8	108.1	107.3	106.1	105.7	104.5	105.5	105.5	106.1	105.9
5*.....	106.8	105.9	105.6	105.0	102.9	101.7	107.9	died.		
6.....	105.0	103.9	104.2	104.7	102.6	102.7	102.2	102.8	103.2	102.1
7*.....	108.6	108.7	109.1	106.6	105.9	104.4	107.2	106.7	107.2	105.4
8*.....	109.6	107.8	108.0	106.4	106.3	99.4	died.			
9*.....	108.2	107.2	106.4	105.9	103.9	died.				
10*.....	106.4	died.								

	September.								
No.	14	15	16	17	18	19	20	21	22
4*.....	104.6	104.8	died.						
6.....	102.0	102.4	103.4	101.6	101.8	102.1	101.6	101.4	101.2
7*.....	104.1	103.5	99.3	99.6	106.0	105.6	died.		

* Post-mortem examinations of these pigs immediately after death revealed the well-known lesions of swine-plague.

In Nos. 1, 3, 4, 6, 7, 8, 9 and 10 the slight rise in temperature on the second day, which dropped again on the following day, was the only observable effect produced by the lymph. In Nos. 2 and 5, which, by the way, were among the first to die, not even this effect was produced. These results would naturally be expected.

It will be seen also that pig No. 6—healthy from the beginning—was, like the rest, not materially affected by the inoculation, but was the only one that lived to see the experiment completed.

The death-rate in this lot, when compared with the death-rate of the entire lot No. II, will be found to be about the same. Of these ten animals, one, or ten per cent. (the healthy one in the beginning),

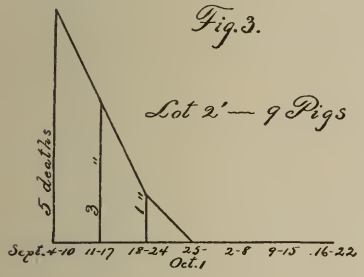
survived. Of the remainder of lot II, comprising 181* animals, whose temperatures were taken eleven days later (it being impossible to get help to do it sooner), fifty-five animals survived, or about thirty per cent.*; a figure as near that furnished by the inoculated lot as could be expected with the great difference in the ratio of healthy to diseased animals in the two lots. Results of experiments made at other times show that a healthy three-months-old pig could receive 12 c.c. of this virus without any permanent injury.

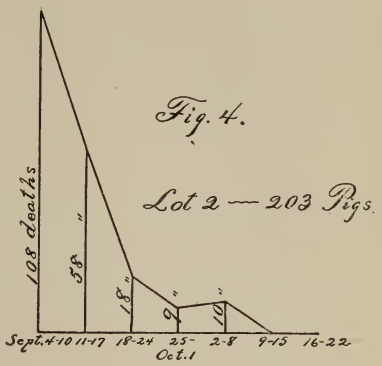
As stated, it was the intention to take the temperatures of the remaining 302 pigs immediately after those of lot II[1] had been taken, but proper arrangements could not be made for this until eleven days later—September 6. By this time ninety-nine of this lot had died, leaving only 203 animals, and before the 8th of September, when all the temperatures had been taken, twenty-two more died, leaving only 181 with a recorded temperature. The temperatures of these 181 animals ranged from 101.5° F. to 109.6° F.; twenty-three had temperatures exceeding 108° F.; sixty-nine had temperatures of 105° F. or below; thirty-seven of the latter had temperatures of 104° F. or below; of this lot of thirty-seven, twelve had abnormally low temperatures. Many with temperatures below 103° F. and all with temperatures below 102.4° F. were emaciated and scrubby looking and were discarded. This left fifty-seven animals in apparent good condition, with temperatures at or below 105° F. Of these fifty-seven, twenty-five had temperatures at or below 104° F.; these were kept in a separate lot, and observed for the purpose of determining whether the temperatures could be practically utilized for diagnostic purposes. At present writing, December 30, these pigs without exception are still alive and thrifty, and further comment may be unnecessary. Unfortunately the other thirty-two that had temperatures between 104°F. and 105° F. were turned in with the discarded lot. Of that lot, which then numbered 156 pigs—just thirty survived. From experiments that we made later and which are still in progress, it seems very reasonable to assume that most of these thirty pigs were included in the thirty-two that had temperatures between 104° F. and 105° F. Assuming this to be the case, and assuming also that the ninety-nine animals that died between August 26 and September 6, could have been recognized as diseased on the day lot II[1] was picked out, and this seems to be a very reasonable assumption, we find, on comparing the death-rate in lot II (after the ten pigs designated as lot II[1] had been separated) with the death-rate in lot II[1] (the virus-experiment lot), that it was almost exactly the same in both lots, the difference

*Beginning August 26, which would be nearer correct, these figures would read 302 animals and 18.2+ per cent., respectively.

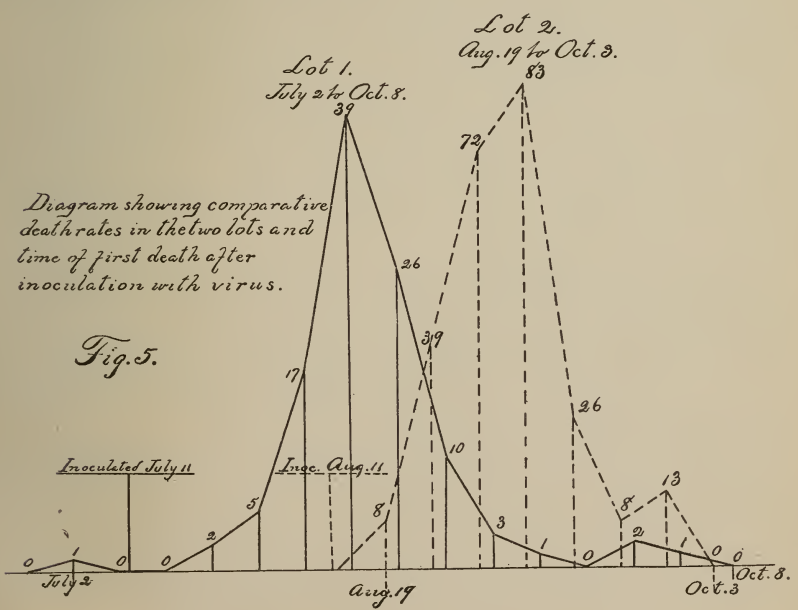
being in favor of lot II[1]. From this we can only conclude that the excessive dose of virus in this case had no effect at all in increasing the rate of mortality.

The following diagrams illustrate graphically the comparative weekly death-rate in the two lots :





Comparing the death-rates in the two lots for the period between August 26 and September 4 (*nil* in lot II[1] and forty-eight in lot II), it would seem almost that it had been retarded by inoculation, but we will leave that point undiscussed.



Is it possible that the virus used for protective inoculation against swine-plague can be the cause of an outbreak of the disease?

This is a question of vital importance and must be answered before we can hope to resort to protective inoculation as a means of combating swine-plague. When improperly or carelessly prepared virus is thus used, there is no doubt but that the disease can be disseminated through its agency. When, however, carefully prepared material is used, material that comes up to a certain standard of virulence and does not exceed this beyond limits allowed for in the prescribed dose for the species for which it is intended, it may be answered that there seems to be no ground for such apprehension.

The regular dose of this material per animal is from one-tenth to one cubic centimeter, according to age and size of the animal, and it has been shown by experiments conducted at this station that an animal three months old (the most susceptible age almost) can receive twenty-five times this amount without any serious permanent effect. Thus this danger does not seem to be a great one. As far as the reliability of the material used in our experiments with the College hogs is concerned, it may be said that of all material used check flasks were kept on hand. These check flasks contained exactly the same kind of material as those actually used. They were afterwards examined, when *other pigs* were inoculated with them, and proved to consist of pure cultures of *Bacillus suis.* The *other pigs* referred to are the lot of ten designated as lot II[1] and pigs inoculated in different parts of the state for the owners. In no case was there cause for that question to arise. In one word—all of our observations point to a negative answer to the question above asked. However, the outbreak of swine-plague in the College herd has taught us a valuable lesson.

From the very beginning of our experiments, which dates back more than a year, we have insisted on inoculating healthy, unexposed pigs only. We were naturally at the mercy of the owner of the pigs to get at the facts in such cases, but fortunately were thus far never deceived in this respect. We have not yet inoculated an infected herd for any private owner of swine.

From the very beginning, also, we were, and of course still are, strenuously opposed to the inoculation of so-called stock pigs that have been bought up from all over the country for the purpose of fattening. This method is a poor one at the best, but when the factor of swine-plague infection is considered the practice cannot be too severely condemned. It is both foolish and dangerous.

We have found that pigs of this kind can be in apparently perfect

health, may be fat, thrifty, vigorous, have a good appetite, etc., and the only symptoms of disease of any kind that can be recognized will be an abnormal temperature, a symptom to which the average farmer usually pays little or no attention, and from its nature it cannot be expected that he should. The pig's normal temperature is subject to considerable variation, ranging from 102° F. to 105° F., and in some cases exceeding even these extremes. Breed, age, sex, environment and other factors all exert an inflence. We have found that a herd of otherwise *thrifty* pigs can be infected with the germs of swine-plague for a period of thirty-three days at the very least, before the first deaths occur.

On September 9, 1899, Mr. John Warner, whose farm is six miles west of Manhattan, requested us to inoculate his pigs with protective virus. His neighbor, across the road, had lost almost 100 out of a lot of 300 or more hogs, and the death list was increasing rapidly. We were apprehensive concerning the condition of Mr. Warner's pigs. We took, and recorded, the temperature of each pig. In one lot of twenty-four pigs, four months old, kept separate from the rest, the temperatures ranged from 103.4° F. to 107.2° F.

One had a temperature of 107.2° F., and one a temperature of 107.1° F. We killed the one with the higher temperature. The post-mortem examination revealed a peculiar hemorrhagic condition of the border of the spleen, noticed also in other pigs from the College herd that died of swine-plague. Bacilli could not be demonstrated, but we assumed it was cholera, acted accordingly, and advised Mr. Warner to send the rest of his pigs that were in proper condition for it to the shambles. He retained the lot of twenty-four above mentioned and a number of brood sows. Two of these had eight ten-day-old pigs. The temperatures of these pigs ranged from 103.8° F. to 104° F. They were apparently in perfect health. Within ten days these pigs died of swine-plague (diagnosis verified by microscopic examination for Bacillus suis). On October 12 or 13 (date determined by the owner on the 19th), the first pig in the lot of twenty-four, above referred to, died of swine-plague. This was thirty-three or thirty-four days after the first symptoms of the disease appeared in the lot.

This statement alone is sufficient to show the risk a farmer takes when he goes into the hog-buying business in the cholera season. Our advice is to "keep out of that kind of business." It shows another thing, viz.: the care that we, as experimenters, must exercise when we inoculate pigs with protective virus. If we should unknowingly inoculate a herd thus infected, the foregone conclusion, when the pigs began to die, would be that the inoculation would be held responsible for the result. We have escaped such accusations in the past, and in

the future we hope to avoid them with a still greater degree of caution by refusing absolutely to inoculate pigs which we did not have the opportunity previously to examine personally with a clinical thermometer. We have in this way examined over 1000 pigs, with results that are gratifying in the extreme.

After carrying on our experiments in this manner for a sufficiently long course of time, we hope that the results gained will be trustworthy, be they for or against this method of protective inoculation. Although we feel that the proper use of the virus could do little harm where an infected herd was treated with it, it would be unwise to expose the method to premature and misplaced criticism before final definite results are gained from accurate experiments. The case of the College herd is one that we must be on our guard not to have repeated.

In conclusion, a few remarks as to our method of carrying on our experiments with protective inoculation.

Although this Station is conducting original experiments with serum treatment for hogs already affected with cholera, that subject will not be discussed here.

The virus for protective inoculation is furnished by Prof. H. J. Detmers, of Columbus, Ohio. It consists of a pure attenuated culture of *Bacillus suis*, put up in hermetically sealed flasks, each containing 100 c.c. of virus. The cost of this material is three dollars per flask, containing virus sufficient to inoculate from 100 to 200 or more pigs. The virus to inoculate the College herd was furnished gratis by Professor Detmers. On account of the lack of funds at our disposal for this purpose, the farmers whose hogs we inoculate are asked to pay actual expenses and $3.10 per flask for virus used. The additional ten cents is to pay expressage.

Following is an outline of the method pursued:

As soon as possible after receiving a request to inoculate a herd of hogs, and with this request an agreement on the part of the owner to pay the expenses of the trip and the cost of the virus, a member* of the Veterinary Department visits the herd in question. A careful examination of the general appearance of the herd is made, the sanitary condition of pens and enclosures is inspected, notes are taken on the methods of feeding and otherwise caring for the animals; then the rectal temperature of each individual pig is taken and recorded. If at the end of the examination these temperatures, together with the general appearance and other conditions of the herd, indicate a healthy condition of the herd, the pigs are inoculated, and the owner is in-

* Most of this work has been done by Mr. A. T. Kinsley, B. Sc.

structed to make such improvements in sanitary conditions as we think necessary. Only three-fourths of the entire number of animals in the herd are inoculated. The other fourth is marked by tagging the left ear with an ear mark bearing a running number and the letters "Kas. Ex. Sta." In case an infection occurs these will serve as a check lot. We have concluded that this is the only satisfactory way of carrying on this experiment.

Thus far we have recorded temperatures of 1242 pigs. This does not include the College pigs. Only 955 of these were inoculated, because in some herds we found swine-plague already existing, and although no deaths had at that time occurred, our diagnosis, which was made principally with the aid of the clinical thermometer, soon proved to be correct when we received a report from the owner to the effect that his hogs were dying.

Of the 955 pigs above mentioned, not one has yet died of swine-plague, although to our certain knowledge several herds have been exposed to the disease. But in the course of time alone can the real value of these inoculations be ascertained.

This method of protective inoculation seems to be a rational one, and we believe that the possibility exists that it can be so perfected as to be practical value. Our experiments are intended to give light on this subject. As yet we are not recommending protective inoculation for the prevention of swine-plague or hog-cholera—we are simply asking the swine owners of Kansas to help us solve the question of its advisability.

Summary.

1. The proper use of Detmers' virus for protective inoculation against swine-plague does not seem to be attended with serious results as far as the use of the mere virus is concerned.

2. Care must be exercised in using virus of this nature, in order to avoid the inoculation of already infected swine and thus arrive at misleading results. Only such persons as have made a careful study of this disease can be expected to recognize it in its early stages.

3. To determine the presence or absence of swine-plague in a herd of swine concerning whose history nothing is known except the owner's statements, it is absolutely essential to determine the body temperature of every pig in the herd, and then base a diagnosis on the results of the temperature and the surrounding conditions.

4. Perfectly healthy swine can receive large doses of attenuated cultures of the swine-plague bacillus without harm.

5. The cause of the outbreak of swine-plague in the College herds was the presence of a number of pigs suffering with a chronic form of the disease at the time the pigs were purchased.

6. The pig that died July 2 was very probably one of these. The same must be said of the last pig inoculated in lot I, to which we referred on pages 8, 9.

7. It has been reported from several reliable sources that the pigs comprising lot I had swine-plague, or had been exposed to swine-plague-infected hogs, before they were sold to the Experiment Station. This alone is sufficient to explain the presence of the disease and make all theorizing needless.

8. Buying stock hogs in the swine-plague or cholera season, or at any other time, and shipping these by rail or by any other route, is a dangerous practice.

9. Farmers should breed and feed their own hogs.

10. When buying breeding animals seek reliable dealers in regions where swine-plague does not exist. This applies also to the purchase of all other farm animals, since any of them can be the means of spreading this disease.

EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN No. 92—MARCH 1900.

FARM DEPARTMENT.

H. M. COTTRELL, M. S., Agriculturist.
D. H. OTIS, M. S., Assistant in Dairying.
J. G. HANEY, B. S., Assistant in Field and Feeding Experiments.

A NEW DROUGHT-RESISTING CROP—SOY BEANS.

THE Kansas Experiment Station began raising soy beans in 1889, and has raised them every year since—in 1899 having seventy acres in this crop. We have found the soy bean to stand the drought as well as Kafir-corn or sorghum; it is not touched by chinch-bugs; the grain is a richer feed than linseed-meal, and the plant enriches the soil on which it is grown. We believe that in 1900 the soy bean should be tried on a small scale by every Kansas farmer.

DESCRIPTION OF THE SOY BEAN.

The soy bean is an erect-growing plant, one and one-half to three and one-half feet in height, with a stiff, woody stem, having numerous branches like a miniature tree. The foliage is heavy and the plants start to branch close to the ground. The branches are thickly covered with pods, which usually contain two to three beans to the pod.

The soy bean was brought from Japan, where it is extensively cultivated for human food, taking the place of beef on account of its richness in protein. Because of its peculiar flavor but few Americans like it.

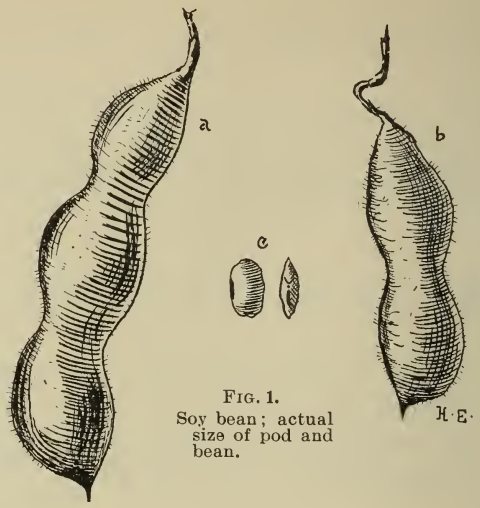


FIG. 1.
Soy bean; actual size of pod and bean.

VARIETY TO PLANT.

Kansas farmers should plant the Early Yellow soy bean. The Kansas Experiment Station has tried many other varieties, and the Early Yellow is the only sort that we have found that is satisfactory under Kansas conditions. Other kinds either yield too little or the crop does not mature during our season. In the spring of 1899 we issued a press bulletin describing the merits of the soy bean and recommending the farmers to give the crop a trial. The College had no seed for sale and farmers ordered from the seed men, simply writing for soy beans. As long as the supply of Early Yellow soy lasted orders were filled with it, and the crops are reported satisfactory. After this supply was exhausted the seed men filled the orders with the Late Yellow soy, a variety that matures in Georgia and Alabama. Kansas farmers who planted the seed of this late variety report that but a small portion of the crop matured, the rest being killed by frost. Early Yellow soy beans planted May 12, 1899, were harvested August 23; planted after wheat, July 14, 1898, were ripe October 9.

PLANTING.

The soy bean should not be planted until the ground becomes warm and the danger of severe frost is over. While the plants may not die if the seed is put in earlier, they do not thrive. No extra growth is gained by too early planting, and the weeds are more likely to grow and make more cultivation necessary. We usually begin putting in soy beans as soon as we have finished planting corn. The beans should be planted in rows thirty to forty-two inches apart, with the single beans dropped one to two inches apart in the rows. One-

half bushel of seed per acre is required. The ground should be in good tilth, and the weeds thoroughly killed just before the beans are planted.

We prefer surface planting. Shallow listing is sometimes successful, but we have lost several crops from listing by heavy rains falling before the beans came up, filling the furrows so full that the young plants were killed. Several Kansas farmers have reported good stands by listing, then filling the furrow nearly full with the cultivator and planting the beans in the shallow furrow that is left.

The beans may be planted with a grain-drill or with a corn-drill, having the plate drilled to drop right. At the College we plant with an eleven-hole grain-drill, stopping all holes but the two outside ones and the middle hole. This puts the beans in rows thirty inches apart. We prefer this distance where the teams are trained to work in narrow rows.

CULTIVATING.

We cultivate the same as corn, using the two-horse cultivator with small shovels and taking great care not to ridge the ground. Level culture is necessary to harvesting a full crop. The ground should be kept clean, free from weeds and grass, and we prefer the shallow tillage which secures a good earth mulch.

HARVESTING.

The crop should be harvested when the pods turn brown and before the beans are fully ripe. If left until the beans become thoroughly ripe the pods will open and the beans will be scattered on the ground.

The only satisfactory way we have found for harvesting the crop is to cut the plants off just below the surface of the ground and rake them into windrows with a horse-rake. Where not over ten acres are grown this cutting can be done by removing the shovels from a two-horse cultivator and bolting to the inner shank of each beam a horizontal knife about eighteen inches long, the knife set out from the cultivator and sloping back from point of attachment to point so as not to clog. Any blacksmith can make these knives. The cut shows a knife made for this purpose from an old knife belonging to a stalk-cutter. With such an arrangement two rows are cut at a time, the knives being set to cut the plants just below the surface.

Where more than ten acres of soy beans are grown, it will pay to harvest them with a regular bean harvester. We tried a number of these harvesters during the summer of 1899, and can recommend bean harvesters made by Chas. H. Bidwell, Medina, N. Y., and the Le Roy Plow Company, Le Roy, N. Y.

As soon as cut, the beans should be raked into windrows and immediately shocked, and left to cure in the cocks. The thrashing may

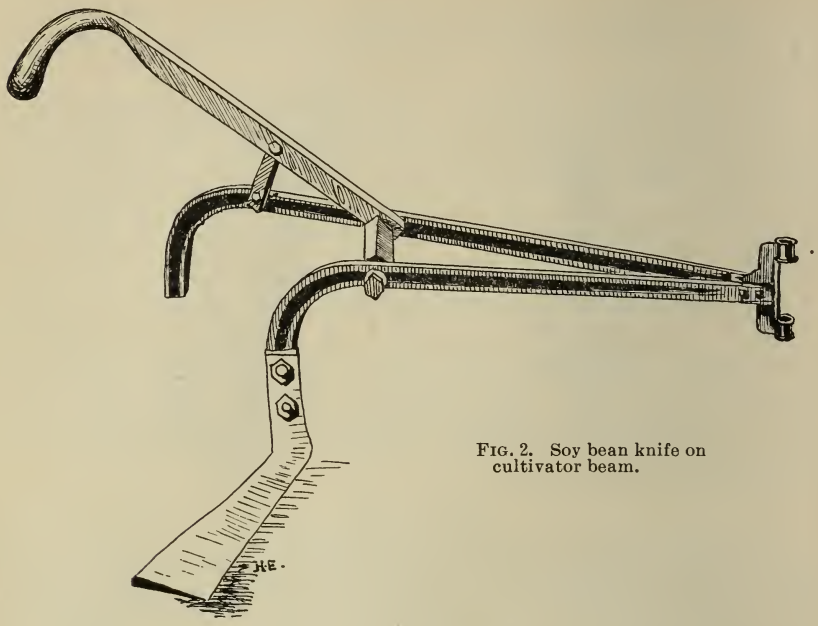


FIG. 2. Soy bean knife on cultivator beam.

be done with the ordinary grain thrasher, using all blank concaves, and running the machine slow enough to prevent cracking the beans.

YIELD.

The Early Yellow soy bean, planted in the spring, will yield from ten to twenty bushels per acre, depending upon the soil and season. The College farm is upland. In 1898 thirty-five acres of soy beans were grown, with an average yield of thirteen bushels per acre. In 1899 seventy acres gave an average yield of fifteen and one-half bushels per acre. With sufficient moisture to germinate them, a crop of soy beans can be grown after wheat and oats have been harvested. In 1896 the yield on the College farm on ground after wheat was eight bushels per acre; in 1898, six and one-fourth bushels. With linseed-meal at twenty-five dollars per ton, these crops after wheat would be worth $6 and $4.68 per acre. In addition to these returns we received the benefit of increased yields from succeeding crops.

Farmers with better ground than ours report a yield of twenty bushels per acre, using our seed.

FEEDING VALUE.

Most Kansas feeds, with the exception of alfalfa, are deficient in protein, and have too much carbohydrates. Protein is the material in food that is needed to form flesh, blood, and milk. Carbohydrates in the food form fat in the body and furnish the animal heat. Soy

FIG. 3. THE SOY BEAN.

beans are extremely rich in protein. The following table shows the digestible nutrients of soy beans and several of our common feeds:

Feed.	Digestible nutrients, pounds per 100 lbs. feed.		
	Protein.	Carbo-hydrates.	Fat.
Soy beans	***29.6***	***22.3***	***14.4***
Flaxseed	20.6	17.1	29.0
Linseed-meal—old process	28.8	32.8	7.1
Bran	12.3	37.1	2.6
Oats	9.3	48.3	4.2
Corn	7.8	66.7	4.3

We have not had a sufficient quantity of soy beans to make extensive experiments of their feeding value for cattle. So far as we have tested soy-bean grain we have found it to take the place and have about the same effect as linseed-meal for feeding steers, dairy cows, and calves. The soy beans are richer in protein and fat than linseed-meal; they have the same laxative effect, and, when fed to cows giving milk, tend to soften the butter the same as linseed-meal. Farmers who have a sufficient amount of alfalfa do not need soy beans for cattle, but farmers not having alfalfa should feed soy beans. Three to four pounds of soy-bean meal per day, added to the ordinary winter ration of the Kansas dairy cow, will increase the flow of milk and improve the texture of the butter. Kansas farmers who desire to raise all the feed given their steers, cows and young stock should grow soy beans without fail, unless they have alfalfa. We have always fed soy beans ground to cattle.

We have made a number of tests of the value of soy beans for fattening hogs. We have ground the beans used in these experiments; but for ordinary feeding, where accurate work is not necessary, soy beans for hogs may be thrashed and fed whole, or the unthrashed stalks may be given and the hogs will pick out the beans. Following are the results obtained in five tests of soy beans for fattening hogs:

1. Hogs seven and one-half months old, averaging 188 pounds each, were fed seven weeks, when they were ready for market, with the following results:

	Average gain per hog.	Gain per bus. of feed.	Feed per 100 lbs. gain.
Kafir-corn meal	90.6 lbs.	11.9 lbs.	471 lbs.
Kafir-corn meal four-fifths, soy-bean meal one-fifth	103.8 "	13.9 "	409 "

This experiment shows that by adding soy beans to the Kafir-corn a saving of thirteen per cent. was made in the amount of feed required to make 100 pounds of gain.

2. Pigs six months old, averaging 122 pounds each, were fed twelve weeks, with the following results:

	Average gain per hog.	Gain per bus. of feed.	Feed per 100 lbs. gain.
Kafir-corn meal	102.0 lbs.	10.0 lbs.	559 lbs.
Kafir-corn meal four-fifths, soy-bean meal one-fifth	146.0 "	13.9 "	408 "

This experiment shows a saving of twenty-seven per cent. by adding the beans to the Kafir-corn.

3. Weaning pigs were put on experiment November 22 and fed sixteen weeks. In addition to the grain they were allowed the run of an alfalfa pasture. Snow fell in December and allowed slight picking thereafter. The results, not considering the pasture, were as follows:

	Average gain per hog.	Gain per bus. of feed.	Feed per 100 lbs. gain.
Kafir-corn meal	74.2 lbs.	10.3 lbs.	542 lbs.
Kafir-corn meal two-thirds, soy-bean meal one-third	129.2 "	15.3 "	374 "
Corn-meal	82.6 "	11.6 "	484 "
Corn-meal two-thirds, soy-bean meal one-third	120.4 "	15.5 "	369 "

Showing a saving in amount of feed required to make 100 pounds of gain of thirty-one per cent. by adding soy beans to the Kafir-corn, and of twenty-four per cent. by adding soy beans to the corn.

4. Hogs were purchased that averaged 126 pounds each, and were fed nine weeks, with the following results:

	Average gain per hog.	Gain per bus. of feed.	Feed per 100 lbs. gain.
Kafir-corn meal	52.4 lbs.	7.5 lbs.	749 lbs.
Kafir-corn meal four-fifths, soy-bean meal one-fifth	97.8 "	12.1 "	468 "

This experiment shows a saving, by adding soy beans to the Kafir-corn, of over thirty-seven per cent.

5. Hogs were purchased that averaged 140 pounds each, and were fed fifty days, with returns as follows:

	Average gain per hog.	Gain per bus. of feed.	Feed per 100 lbs. gain.
Kafir-corn meal	44.1 lbs.	8.6 lbs.	653 lbs.
Kafir-corn meal four-fifths, soy-bean meal one-fifth	86.6 "	13.0 "	435 "

This experiment shows a saving in feed of thirty-three per cent. by adding the soy beans to the Kafir-corn.

These experiments show that when soy beans were fed with corn or Kafir-corn for fattening hogs a saving was made in the amount of feed needed to make 100 pounds of gain of 13, 24, 31, 33 and 37 per cent., the amount varying in different experiments. Can the Kansas farmer afford to go without the soy bean and lose this saving?

In feeding hogs, mix the Kafir-corn and soy beans just before feeding, and add sufficient water to thoroughly wet the mixture; soaking for any length of time gives less returns.

We have not tried soy beans for sheep feeding, but many feeders

report this crop as valuable for sheep feeding as we have found it for feeding hogs.

Soy beans make a pasture that is greatly relished by hogs and they make good gains on it while the pasture lasts, but soy-bean pasture is not sufficiently lasting to be profitable under most circumstances. Soy-bean vines fed green make a good milk-producing food.

We have not found the Early Yellow soy bean to be a profitable hay crop. Other soy-bean raisers have reported so favorably on soy beans for hay that we shall try other varieties and new methods for making soy-bean hay. We have not found any kind of stock that likes the fodder after the ripe beans are removed.

COST OF PRODUCTION.

Kansas farmers who have tried soy beans on a large scale report that with ordinary prices for farm labor it costs forty cents per bushel to raise them. This includes all expense from preparing the ground for planting to storing the thrashed beans in the bin, but does not include rent.

During the summer of 1899 we kept an account of the cost of raising soy beans on fields containing a total area of sixty acres. Labor cost $1.25 per day for a man and $2.50 per day for a man and team. The cost per acre was: Preparation of land, $1.35; planting, 30 cents; cultivating, $2; hoeing, 70 cents; harvesting, $1.40; thrashing, $2.57; total, $8.32. The yield of the 60 acres was 932 bushels, making the total cost per bushel nearly 54 cents.

FAULTS OF THE SOY BEAN.

Soy beans stand drought well and are not touched by chinch-bugs, but are a favorite feed for rabbits. The College sent out many small lots—one and two quarts in a lot. Most of the reports from these small lots said that the beans came up well, and while still young were entirely destroyed by rabbits. For this reason we now refuse to sell less than one bushel of beans, and recommend Kansas farmers to plant five acres for a trial patch. One bushel will plant two acres, and where two to five acres are planted the rabbits can take the outside rows and there will be enough left to give a fair test.

If the beans are allowed to become ripe before being cut they sometimes shell badly, farmers occasionally reporting a loss of half or more of the crops from this cause. The beans should be cut before becoming ripe. Beans cut when the pods begin to turn brown shell but little.

Accidents or other pressing labor may prevent the grower from cutting at the right time. In this case the beans may be saved by

turning pigs on the field after the crop is harvested. The pigs will pick up the scattered beans.

FERTILIZING VALUE.

The soy bean not only furnishes a highly concentrated feed, but it improves the soil on which it is grown. Henry Rogler, one of our graduates, reports an increase in large fields of five bushels of wheat per acre on land where soy beans had previously been grown over the yield from the same kind of land that had not been in soy beans. We have noticed an increased yield in crops of all kinds that have followed the soy bean.

Where farmers in eastern Kansas have had difficulty in getting alfalfa to grow, they will find that a crop of soy beans raised just before seeding to alfalfa will aid them in getting the alfalfa started, as the soy bean leaves in the surface soil just the material needed for the young alfalfa plants.

Will it Pay the Kansas Farmer to Raise Soy Beans?

The soy bean stands drought as well as Kafir-corn or sorghum; it is not touched by the chinch-bugs; the grain is a richer feed than linseed-meal, and the plant enriches the soil on which it is grown. It will cost the Kansas farmer from forty to fifty-five cents per bushel to raise the soy bean—thirteen to eighteen dollars per ton. Pound for pound, soy beans are worth a little more than oil-meal, and feeders are paying twenty-four to thirty dollars a ton for oil-meal.

Kansas dairymen should raise soy beans. A bountiful supply of protein will greatly increase the milk yield. Soy beans are rich in protein and our ordinary Kansas feeds are poor in this material. Three to four pounds of soy beans per day added to the usual dairy ration of hay, fodder, sorghum and corn will increase the winter milk yield of the average Kansas cow from 25 to 100 per cent.

Kansas hog raisers should grow soy beans. Fed to young pigs, soy beans will make them grow more rapidly and have better health. Fed to fattening hogs, soy beans will induce them to eat more, make more gain for each bushel of feed eaten, and shorten the fattening period.

The Kansas stockman should raise soy beans, as soy beans fed to young stock will push their growth and enable them to "keep the calf fat," which is so necessary to economical feeding. Fed to fattening animals, soy beans will produce the same results as linseed-meal at less cost.

Kansas sheep men should raise soy beans and secure the results obtained from linseed-meal with a home-grown feed at a reduced cost.

Kansas crop growers should raise soy beans to quickly and cheaply increase the yield of their other crops.

Plant five acres or more of soy beans this spring and give them a trial.

OBTAINING THE SEED.

Most seed men sell soy beans, listing them as soy beans, soja beans, or coffee beans. The following farmers report having raised soy beans in large quantities in 1899:

Hon. Geo. M. Munger, Eureka, Kan.
A. E. Clark, Pleasant Hill, Kan.
M. L. Dickson, Edgerton, Kan.
Wm. C. Lee, Manhattan, Kan.
H. H. Clothier, Vera, Kan.
D. L. Beale, Montana, Kan.
O. E. Simmers, Abilene, Kan.

Soy beans intended for seed should be stored in shallow bins; kept in large quantities or in sacks they heat, and will not germinate. Farmers buying seed should take the beans out of the sacks as soon as received, and spread them out in a dry place until planting. Last spring a farmer bought a sack of soy beans and planted part of them as soon as received, securing a good stand. A rain stopped the planting for two weeks, when the remainder of the beans were put in, but failed to grow. They had become heated in the sack.

EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN No. 93—MARCH 1900.

FARM DEPARTMENT.

H. M. COTTRELL, M. S., Agriculturist.
D. H. OTIS, M. S., Assistant in Dairying.
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KAFIR-CORN.

KAFIR-CORN is grown in every county in the state, Sec. F. D. Coburn, of the State Board of Agriculture, reporting 582,895 acres grown in Kansas in 1899. Notwithstanding this general distribution and large acreage, we are constantly receiving letters asking for information in regard to the raising and feeding of this crop.

Kafir-corn is comparatively a new crop, Secretary Coburn first listing it in 1893 and showing 46,911 acres for the state.

DESCRIPTION.

Kafir-corn belongs to the group of sorghums that contain but little sugar. The plants grow erect, with thick, short-jointed stalks, bearing broad, deep-green leaves. The plants average $4\frac{1}{2}$ to $6\frac{1}{2}$ feet in height. The heads are compact, stand erect, and average from ten to fifteen inches in length.

Kafir-corn is raised both as a grain crop and as a hay crop. Its greatest value is for grain and this bulletin will treat of it chiefly as a grain crop.

VARIETIES.

Kafir-corn has been raised on the Kansas Agricultural College farm for eleven years. We recommend two varieties—the red and

the black-hulled white. For the first seven years we raised the red. The black-hulled white was then tested, and from 1896 to 1898 the two varieties were grown side by side, the red giving an average yearly yield of thirty-seven bushels per acre and the black-hulled white forty-three bushels per acre. The yield of grain per acre by years is as follows:

	Red.	Black-hulled White.
1896	41 bus.	48 bus.
1897	41 "	48 "
1898	28 "	33 "
Totals	110 bus.	129 bus.
Averages	37 "	43 "

We now raise the black-hulled white only. In western Kansas many farmers raise the red, thinking it a little hardier and earlier. In central Kansas some of our feeders raise both the red and the black-hulled white and feed alternately, the stock seeming to relish the change.

Our records show the red to be from a week to ten days earlier than the black-hulled white, but this difference is of but little importance in central Kansas. Kafir-corn planted on the College farm the middle of May is ripe the middle of September.

THE SEED.

Kafir-corn heads vary considerably in form and compactness. We prefer seed from long, closely compacted heads. It is best to save Kafir-corn intended for seed in the heads until planted, and the heads should either be hung up separately or else be loosely piled and kept dry and well aired. When thrashed and stored in large quantities, Kafir-corn will heat sufficiently in damp weather to destroy the germinating power of the seed. Poor stands are common every year all over the state from this cause.

PLANTING.

Kafir-corn is a warm-weather plant, makes a slow early growth, and should not be planted until the ground becomes warm. We usually plant immediately after corn planting is completed. Nothing is gained by earlier planting. Planted too early, the stand of Kafir-corn is frequently so poor that a late replanting is necessary, and if a good stand is secured the growth of the young plants is so slow that the weeds forge ahead and extra cultivation is necessary.

On cold soils and on soils that wash surface-planting is best. Plow the ground—in the fall, if practicable—thoroughly pulverize it just before planting, and plant in rows three to three and one-half feet apart, dropping single seeds an inch apart in the row. Plant about the same depth as wheat.

FIG. 1.
Red Kafir-corn.

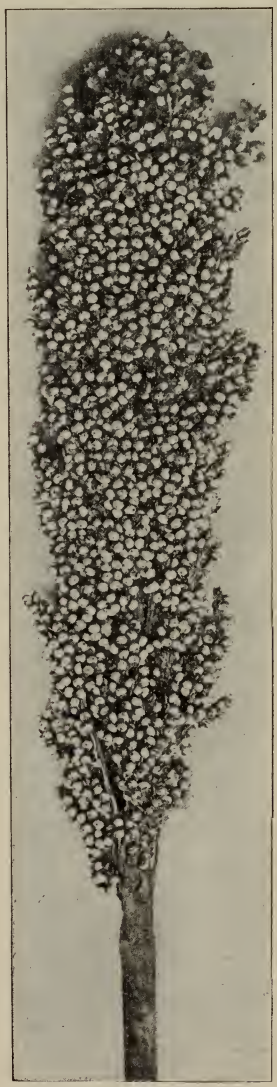


FIG. 2.
Black-hulled White Kafir-corn.

We plant Kafir-corn with a grain-drill, stopping all but two holes, using a bushel of seed to each five acres. The seed weighs fifty-six pounds per bushel.

Kafir-corn may also be planted with either a one-horse corn-drill or a two-horse corn-planter with drill attachment. With either of these machines dropping plates must be used that are drilled to drop Kafir-corn at the proper distance.

On warm soils and in late planting listed Kafir-corn does well, the only difficulty being that a heavy rain before the plants come up or while they are small may fill the furrows with soil and ruin the stand.

Whatever method of planting is used, the weeds should be killed just before the Kafir-corn is planted and a mellow seed-bed provided. The ground should be compacted around the seed to insure quick starting.

In 1898 heavy late floods destroyed hundreds of acres of wheat and corn on bottom lands in eastern Kansas. These floods came too late for replanting of the lands with corn. We advised using red Kafir-corn and many farmers who accepted our advice secured good crops.

CULTIVATION.

Cultivate Kafir-corn the same as you would corn for a good yield. We give level culture and prefer the two-horse cultivator with four small shovels attached to each beam. Most farmers use the cultivator with two broad shovels to each beam.

After the Kafir-corn has reached a foot in height the shovels should be run shallow, as the roots soon extend from row to row.

HARVESTING.

When grain and fodder are both wanted, Kafir-corn should be cut when the seeds are ripe and put in large shocks. The most convenient machine for cutting is the corn-binder which cuts the stalks and ties them with twine into bundles. Next to this method, for speed and convenience, is cutting with the common sled cutter. For stock cattle and horses the shocks may be hauled directly to the feed lot.

When steers and hogs are to be fattened the grain is wanted without the fodder. Kafir-corn raisers are still looking for a cheap and satisfactory means of harvesting the grain alone. Some feeders run the entire stalks—including the heads—through a thrashing-machine. This takes power, is expensive, and the cut and torn stalks lose flavor, like bread after it is sliced. Others take bundles of Kafir-corn and hold the heads in the thrasher until the grain is knocked off, and then throw the stalks back without letting them pass through the machine. This takes less power than the other method but the fodder has to be handled too much.

FIG. 3. Kafir-corn in the shock.

The cheapest method we have found is to place the bundles on a block and cut the heads off into a wagon with a broad ax.

Headers have been recently put on the market that harvest the heads, leaving the stalks standing where they grew. The work of these headers has not been such as to bring them into general use, but it is probable that they will soon be perfected and that heading will be the best method of harvesting Kafir-corn where grain only is wanted.

Thrashed Kafir-corn grain stored in bins is liable to heat badly in damp weather. No way of avoiding this has been found. In the spring of 1899 we bought a car-load of Kafir-corn that had been thrashed several months and was apparently thoroughly dry when received. The car-load was put in one bin, and when wet weather came began to heat and we had to shovel it over several times.

In western Kansas it is a common practice to head Kafir-corn and pile the heads in stacks until the grain is wanted. This is done to avoid heating of the thrashed grain. Stacked heads are liable to mold in eastern and central Kansas.

YIELD.

The College farm is upland. In the eleven years that we have grown Kafir-corn there has been but one failure to produce grain. In 1894 Kafir-corn yielded no grain, but gave two tons of fodder per acre. Corn the same year yielded us no grain and one ton of fodder per acre. The average yield of grain per acre on the College farm for the past eleven years has been, per year: Kafir-corn, 46 bushels; corn, 34½ bushels. Our highest yield per acre in one year has been: Kafir-corn, 98 bushels; corn, 74 bushels. In the western half of the state the difference in favor of Kafir-corn is greater, as there, in dry years, when corn yields one to five bushels per acre, the yield of Kafir-corn is twenty-five bushels or more.

Yield of Kafir-corn and corn per acre on the College farm:

Year.	Kafir-corn.	Corn.
1889	71 bus	56 bus.
1890	19 "	22 "
1891	98 "	74 "
1892	50 "	30 "
1893	49 "	30 "
1894 (failure).		
1895	43 "	28 "
1896	48 "	39 "
1897	48 "	34 "
1898	33 "	26 "
1899	50 "	40 "
Totals	509 bus	379 bus.
Yearly averages	46 "	34.5 "

We are often asked how the yield of Kafir-corn compares with that of rice-corn, Jerusalem corn, and milo maize. Three years' tests at this station indicated that Kafir-corn was the superior variety for grain and the other varieties were dropped. The yield in bushels per acre for these three years was as follows:

	1889.	1890.	1891.
Red Kafir-corn	71.0 bus	19.0 bus	98.0 bus.
Rice-corn	0.0 "	16.5 "	61.0 "
Jerusalem corn (destroyed by birds all years).			
Milo maize	57.0 bus	2.2 bus	0.0 bus.

The English sparrow destroys the heads of rice-corn and Jerusalem corn on the College farm before the seeds become ripe. In the treeless sections of the western part of the state the sparrows do not bother these varieties and they are good grain yielders, but yield little fodder. Milo maize does well on the College farm in a long season, but in two years out of the three was cut off by frost.

DROUGHT AND CHINCH-BUGS.

Kafir-corn stands the drought better than corn. It will continue to extract moisture from the ground and to grow after the ground has become so dry that corn has become permanently checked. When finally the ground becomes so dry that the Kafir-corn can no longer grow it remains stationary and if the late rains come starts to growing again as though nothing had happened. Corn, under the same conditions, dies. Frequently in Kansas the corn crop is small because, although the rainfall is sufficient and the stalks are vigorous through the season, a few days of hot winds at tasseling time kills the pollen and the kernels of corn do not form. Kafir-corn is not affected in this way.

The thick, short-jointed stalk of Kafir-corn enables it to withstand strong winds much better than either corn or the sweet sorghums.

Kafir-corn has strong feeding powers and heavy root development, especially adapting it to poor soils. It will produce a good yield of

grain on poor land and on uplands where corn will fail except in favorable years.

Kafir-corn is not proof against chinch-bugs and chinch-bugs when very thick will kill it, but an ordinary attack such as will seriously injure corn does not seem to hurt Kafir-corn much. When only a few inches high Kafir-corn is readily destroyed by this pest.

COMPOSITION.

The following table shows the digestible nutrients in Kafir-corn grain and fodder compared with other common feeds:

Grain.	Digestible Nutrients. Pounds per 100 lbs. feed.			Heat units in one pound.	Nutritive ratio 1 to—
	Protein.	Carbohydrates.	Fat.		
Kafir-corn grain	***7.3***	***65.2***	***0***	***1349***	***8.9***
Corn	7.8	66.7	4.3	1567	9.7
Barley	8.9	64.8	1.6	1438	7.7
Oats	9.3	48.3	4.2	1249	6.2
Kafir-corn fodder	***3.5***	***52.8***	***1.3***	***1092***	***15.9***
Corn-fodder	2.0	33.2	0.6	680	17.3
Sorghum hay	2.4	40.6	1.2	850	18.0
Prairie hay	3.5	41.8	1.4	902	12.8
Millet hay	4.5	51.7	1.4	1104	12.2
Alfalfa	10.6	37.3	1.4	948	3.8

KAFIR-CORN FOR FATTENING HOGS.

We have tested the value for fattening hogs of Kafir-corn alone and Kafir-corn combined with other feeds in experiments including 324 hogs.

Two experiments were made to compare Kafir-corn with corn. The hogs in the first trial were fed seven weeks; in the second, twelve weeks. The hogs used in both experiments were pure-bred Poland-Chinas and Berkshires.

Feed.		Ave. weight at beginning.	Gain per hog.	Gain per bus. of feed.	Feed for 100 lbs. gain.
First trial,	Kafir-corn	188 lbs.	68 lbs.	10.33 lbs.	542 lbs.
	Corn	188 "	73.6 "	12.25 "	457 "
Second trial,	Kafir-corn	124 "	132 "	10.93 "	512 "
	Corn	123 "	102 "	11.69 "	479 "

Averaging the results of these two trials, we have 10.6 pounds pork from a bushel of Kafir-corn and 11.9 pounds of pork from a bushel of corn. A bushel of corn is worth more than a bushel of Kafir-corn, but, on the College farm, an acre of Kafir-corn is worth more than an acre of corn. The average yield of grain per acre on the College farm for the past eleven years has been, per year: Kafir-corn, 46 bushels;

corn, 34½ bushels. This shows for the College upland farm an average yield of grain per year to produce 487 pounds of pork from Kafir-corn and 410 pounds of pork from corn.

To secure the best results in fattening hogs with Kafir-corn it should be fed with some feed that is rich in protein. We have had good results in feeding alfalfa hay, skim-milk and soy beans with Kafir-corn for this purpose. The hogs used in these experiments were ordinary mixed-bred hogs purchased of farmers, and did not make the gains per bushel of feed that were made by the College pure-bred hogs.

Hogs fattened in nine weeks gained an average of 52.4 pounds each fed on Kafir-corn meal alone, and 90.9 pounds each fed Kafir-corn meal and alfalfa hay. The hay was fed twice daily, whole, in shallow boxes separate from the grain. The hogs ate 7.83 pounds of hay per bushel of grain. The hogs having the meal alone ate 393 pounds each, while those having hay ate 468 pounds of meal each. The gains per bushel of Kafir-corn meal were: Kafir-corn meal and 7.83 pounds alfalfa hay 10.88 pounds; Kafir-corn meal alone, 7.48 pounds. The hogs fed the alfalfa hay ate more Kafir-corn and made more gain from each bushel eaten. The gain in weight made by hogs fed the hay is over 73 per cent. more than the gain made by the hogs fed grain alone. The feeding also shows a gain of 868 pounds of pork per ton of alfalfa hay fed.

These results are not due to feeding value of alfalfa hay alone, but also to its influence in aiding the hogs to better digest the Kafir-corn. The alfalfa hay also gave a variety to the ration, making it more appetizing and inducing the hogs to eat more grain. Valuing the hay at $3 per ton and fat hogs at 3 cents per pound live weight, the Kafir-corn fed alone brought 22.4 cents per bushel; the Kafir-corn fed with alfalfa hay brought 31.4 cents. The hay fed was of the best quality, carefully cured, with all the leaves on.

A second trial was made of feeding alfalfa hay with Kafir-corn to fattening hogs, using a hay of poor quality that had lost many of the leaves in curing. The hogs were fed 50 days and the gain per hog fed whole Kafir-corn alone were 45.6 pounds each, and those fed whole Kafir-corn and alfalfa hay were 68.5 pounds each. The hogs fed the hay ate 343 pounds of grain each, while those having grain alone ate 291 pounds each. The gains per bushel of feed were: Kafir-corn whole and 14.58 pounds of alfalfa hay, 11.17 pounds; Kafir-corn alone, 8.75 pounds. This experiment shows a gain in feeding poor alfalfa hay with Kafir-corn to fattening hogs of 333 pounds of pork per ton of alfalfa hay.

Hogs averaging 125 pounds each were fed 42 days and 20 head

were used for each method of feeding. Hogs fed whole Kafir-corn alone ate 266 pounds each and gained 41.7 pounds each. Hogs fed whole Kafir-corn and skim-milk ate, per hog, Kafir-corn 330 pounds, skim-milk 210 pounds, and made an average gain per hog of 66 pounds each. The hogs having the milk ate more grain and gained more for each bushel eaten. In the 42 days the hogs fed Kafir-corn and milk gained 58 per cent. more than the hogs fed Kafir-corn alone. The milk used was sterilized skim-milk from a creamery. In this experiment one bushel of Kafir-corn alone made 8.78 pounds gain, and one bushel of Kafir-corn and 35.6 pounds of skim-milk made 11.2 pounds gain.

We have made many trials to test the value of adding soy beans to Kafir-corn, in fattening hogs.

Hogs 7½ months old, averaging 188 pounds each, were fed seven weeks, when they were ready for market, with the following results:

	Average gain per hog.	Gain per bus. of feed.	Feed per 100 lbs. gain.
Kafir-corn meal	90.6 lbs.	11.9 lbs.	472 lbs.
Kafir-corn meal ⅘, soy-bean meal ⅕	103.8 "	13.9 "	409 "

This experiment shows that by adding soy beans to Kafir-corn a saving of 13 per cent. was made in the amount of feed required to make 100 pounds of gain.

Pigs six months old, averaging 122 pounds each, were fed twelve weeks, with the following results:

	Average gain per hog.	Gain per bus. of feed.	Feed per 100 lbs. gain.
Kafir-corn meal	102.0 lbs.	10.0 lbs.	559 lbs.
Kafir-corn meal ⅘, soy-bean meal ⅕	146.0 "	13.9 "	408 "

This experiment shows a saving of twenty-seven per cent, by adding the beans to the Kafir-corn.

Weaning pigs were put on experiment November 22, and fed sixteen weeks. In addition to the grain they were allowed to run on alfalfa pasture. Snow fell in December, and allowed slight picking thereafter. The results, not considering the pasture, were as follows:

	Average gain per hog.	Gain per bus. of feed.	Feed per 100 lbs. gain.
Kafir-corn meal	74.2 lbs.	10.3 lbs.	542 lbs.
Kafir-corn meal ⅔, soy-bean meal ⅓	129.2 "	15.3 "	374 "

Showing a saving in amount of feed required to make a hundred pounds of gain of 31 per cent. by adding soy beans to the Kafir-corn.

Hogs were purchased that averaged 126 pounds each and were fed nine weeks, with the following results:

	Average gain per hog.	Gain per bus. of feed.	Feed per 100 lbs. gain.
Kafir-corn meal	52.4 lbs.	7.5 lbs.	749 lbs.
Kafir-corn meal ⅘, soy-bean meal ⅕	97.8 "	12.1 "	468 "

This experiment shows a saving, by adding soy beans to the Kafir-corn, of over 37 per cent.

Hogs were purchased that averaged 140 pounds each, and were fed fifty days, with returns as follows:

	Average gain per hog.	Gain per bus. of feed.	Feed per 100 lbs. gain.
Kafir-corn meal	44.1 lbs.	8.6 lbs.	653 lbs.
Kafir-corn meal $\frac{4}{5}$, soy-bean meal $\frac{1}{5}$	86.6 "	13.0 "	435 "

This experiment shows a saving in feed of 33 per cent. by adding soy beans to the Kafir-corn.

These experiments show that when soy beans were fed with Kafir-corn to fattening hogs a saving was made in the amount of feed needed to make 100 pounds of gain of 13, 27, 31, 33 and 37 per cent., the amount varying in different experiments.

QUALITY OF PORK FROM KAFIR-CORN.

We shipped fifty head of Kafir-corn-fed hogs to Swift & Co., St. Joseph, Mo., for slaughter tests. The different fed lots dressed as follows:

Kafir-corn whole	80.4	per cent.
Kafir-corn meal	80.0	"
Kafir-corn whole and alfalfa hay	79.5	"
Kafir-corn meal and alfalfa hay	79.0	"
Kafir-corn meal four-fifths, soy beans one-fifth	80.0	"

Swift & Co. report "that the hogs showed good, firm flesh, with good distribution of lean and fat on the bellies; the hogs that were fed on Kafir-corn meal and alfalfa hay showing fat of a good, white color not common in corn-fed hogs. The hogs fed whole Kafir-corn alone varied considerably in weight, but were the most suitable for bacon hogs, and a few would have been suitable for English cuts, on account of the evenness of the fat and the good distribution of lean through the bellies."

We shipped eighty head of Kafir-corn-fed hogs to Armour & Co., Kansas City. The different fed lots dressed as follows:

Kafir-corn whole	80.3	per cent.
Kafir-corn and alfalfa pasture	81.0	"
Kafir-corn and skim-milk	81.0	"
Kafir-corn, skim-milk, and alfalfa pasture	80.5	"

Armour & Co. reported as follows: "The hogs fed Kafir-corn alone, flesh irregular and rather soft; the hogs having Kafir-corn and alfalfa pasture, flesh firm, color of fat good; the hogs fed Kafir-corn and skim-milk, flesh firm, fat white, good distribution of fat and lean in the bellies; and hogs having Kafir-corn, skim-milk, and alfalfa pasture, flesh firm, nice white fat, good proportion of fat to lean."

FIG. 4. Pork from hogs fed on Kafir-corn.

KAFIR-CORN FOR STEERS.

Our present Station force has not had funds available to make tests of the value of Kafir-corn for fattening steers. Prof. C. C. Georgeson made a trial at this Station, using five steers in a lot, with the following results:

FEED.	Average weight at beginning.	Feed eaten per steer.		Ave. gain per steer.	Feed for 100 lbs. gain.	
		Grain.	Roughage.		Grain.	Roughage.
Corn-meal .....lbs.	1,036	3,254	1,859	326	997	569
Red Kafir-corn meal "	1,021	3,254	2,060	299	1,086	688
White Kafir-corn meal "	1,025	3,254	2,166	313	1,041	692

The rough feed during the first part of the trial was Kafir-corn fodder, and later alfalfa hay and Kafir-corn fodder were used.

Averaging these gains from Kafir-corn, and taking our yield, there has been raised on the College farm Kafir-corn to supply the grain needed to produce an average, each year for eleven years, of 242 pounds of beef per acre, and corn to produce 194 pounds of beef per acre.

KAFIR-CORN FOR DAIRY COWS.

Kafir-corn grain and alfalfa hay make the cheapest combination of feeds in Kansas for milk production; each of these feeds contains the properties which the other lacks. Fed in the proportion of twenty pounds of alfalfa to eight pounds of Kafir-corn, in such quantities as the cow will eat, a good flow of milk is secured at a low cost, from

which butter can be made of good quality in regard to firmness. All such a ration lacks is variety.

Beginning February 2, 1898, we made a seven-weeks' test in milk production with 18 scrub cows shipped a month previous from western Kansas. It required 1295 pounds of Kafir-corn meal and 2383 pounds of alfalfa hay for 100 pounds of butter-fat. The best cow in the lot required 914 pounds of Kafir-corn meal and 1690 pounds of alfalfa hay per 100 pounds of butter-fat. Alfalfa hay is worth $3 per ton on Kansas farms and Kafir-corn meal not more than 50 cents per 100 pounds. This makes the cost of feed for producing one pound of butter-fat 10 cents for the herd and 7.1 cents for the best cow. All were scrub cows. With these feeds, better cows would have produced butter-fat at less cost.

Kafir-corn fed with alfalfa hay makes a balanced dairy ration. Kafir-corn alone has too much fat- and heat-making materials for milk production; and when fed with prairie, timothy or sorghum hays or corn-fodder, feeds having the same defect, it tends to dry up the cow and, if fed in sufficient quantity, to fatten her. Where this kind of roughage is used, linseed, cottonseed, or soy-bean meals or bran should be fed with the Kafir-corn.

KAFIR-CORN FOR CALVES.

Kafir-corn meal is the ideal grain to feed calves raised on skim-milk. The meal is constipating and overcomes the tendency of the skim-milk to cause scours. In the summer of 1899 we raised 13 calves on skim-milk. The calves fed skim milk, Kafir-corn meal and Blachford's calf meal made an average daily gain of 1.9 pounds each; those fed skim-milk, Kafir-corn meal and flaxseed jelly gained an average of 1.6 pounds each daily; while those fed skim-milk and Kafir-corn meal only gained 1.8 pounds each daily. This shows good daily gains with all the feeds, and that Kafir-corn meal can take the place of rich and expensive meals usually fed calves.

Whole milk is nature's food for the calf. When we skim it we remove the fat, and Kafir-corn meal, rich in starch, takes the place of the fat removed. The Kafir-corn meal should be fed dry to calves and never mixed with the milk. The more the calf chews the Kafir-corn the better it will digest it. Fed in the milk, the Kafir-corn meal is bolted, and much of it remains undigested and has an irritating effect on the calves' digestive tract, tending to produce scours.

Kafir-corn is an excellent feed to give calves after weaning, whether they have run with their dams or have been raised on skim-milk. At any time in his life a calf may be fed regularly all the Kafir-corn meal he will eat.

KAFIR-CORN FOR HORSES.

We have fed Kafir-corn meal to horses doing heavy farm work, and have found it to be a good feed. We feed the same weight of the Kafir-corn as we would of corn. Kafir-corn is generally fed to work horses on Kansas farms, when raised in large quantities. Some farmers grind it, some feed the thrashed grain, and others feed it in the head. Feeding in the head saves all expense of preparation, and the stems of the head being eaten with the grain seem to be of value. To young horses and those not working Kafir-corn may be fed just as it is harvested—stalk and heads—and makes a good feed.

KAFIR-CORN FOR SHEEP.

We have not fed Kafir-corn to sheep at this Station, but have found the sheep feeders in the Kafir-corn sections of the state getting good returns from it when fed with alfalfa.

PREPARATION FOR FEEDING.

Most of our trials of the value of different methods of preparing Kafir-corn for feeding have been made in fattening hogs. The results of these trials are given below. The trials were not made to test this question, but for other purposes. This explains why the methods are not more uniform in the four trials.

		Required to make 100 lbs. of gain.
First trial ...	Whole Kafir-corn, dry	542 lbs.
	Whole Kafir-corn, soaked 48 hours	632 "
	Kafir-corn meal, wet	471 "
Second trial .	Whole Kafir-corn, dry	512 "
	Whole Kafir-corn, soaked 48 hours	550 "
	Kafir-corn meal, wet	559 "
Third trial...	Whole Kafir-corn, dry	655 "
	Kafir-corn meal, dry	749 "
	Kafir-corn meal, wet	691 "
Fourth trial .	Whole Kafir-corn, wet	640 "
	Kafir-corn meal, wet	653 "

In the first trial we lost 16.6 per cent. by soaking the Kafir-corn, and in the second trial the loss was 7.4 per cent. Both trials were made in winter, and there was no loss from souring, as might have happened in hot weather. Only one trial shows a gain from grinding the Kafir-corn, and all others a loss. In the first trial a gain of 15 per cent. was made by grinding; in the second trial the loss from grinding was 9.1 per cent.; in the third trial the losses from grinding were 5.5 per cent. and 14.3 per cent., and in the fourth trial 2 per cent. After carefully watching the feeding during these trials, we think the best way to feed Kafir-corn to fattening hogs is to place it dry in the feeding troughs at the time of feeding, and pour over it sufficient water so that a small quantity of water will be left in the trough after

the hogs have finished eating the grain. Kafir-corn is dusty, and when fed dry starts the hog to coughing severely before a meal is finished.

We have usually fed Kafir-corn ground to cows, calves, and horses, but have not made sufficient trials to determine whether grinding is best for these animals or not. For mature cattle and horses we know that feeding it in the head is a satisfactory method.

We have tried grinding the heads without thrashing. They grind easily in a power Bowsher iron grinding mill; the resulting meal is a good feed for animals who need rougness, and the expense of thrashing is saved.

KAFIR-CORN AS A HAY CROP.

We prefer the sweet sorghums to Kafir-corn for a hay crop, as they give with us a greater yield and more palatable fodder, but many Kansas farmers think Kafir-corn the best.

It may be sown either broadcast or with a grain-drill, putting on from one and one-half to two bushels of seed per acre. The amount of seed will depend upon the richness and condition of the land. Kafir-corn for hay cannot be cultivated, and the stand should be thick enough to keep down the weeds and to furnish slender stalks at the time of cutting. Cut with a mowing-machine when the seed is in the thick milk or dough, and cure in large cocks. In eastern Kansas Kafir-corn hay should be fed before January 1, as it loses its freshness by this date. In western Kansas it will remain palatable for a longer time.

In parts of eastern Kansas it is difficult to cure and keep sorghum hay on account of damp weather. This difficulty can be overcome by sowing sorghum and Kafir-corn mixed half and half. The stalk of the Kafir-corn is much drier than that of sorghum, and the mixed hay keeps better.

Kafir-corn fodder with the heads removed has about the same value as corn-fodder with the ears removed.

DANGER FROM SECOND GROWTH.

If Kafir-corn is cut early a second growth starts up. Usually stock can eat this second growth with safety, but deaths are frequent. Most of these deaths can be explained by the cattle bloating, but sometimes deaths occur where it seems that the green Kafir-corn acts as an acute poison. Cases are reported where animals have broken into a field of Kafir-corn while being driven along an adjoining road and securing only a mouthful or two of the green second growth, have been immediately attacked with symptoms of acute poisoning, and have died in an hour or two. Cattle have been herded in a large field in which was a small patch of second-growth Kafir-

corn; animals have strayed on the Kafir-corn while being driven by the herdsman and secured only a bite or two and have been attacked and died within an hour. Neither veterinarians, chemists nor feeders have been able to explain the cause of such deaths. They are rare, but occur often enough to make it unsafe to allow cattle to pasture green second-growth Kafir-corn. After this second growth has been cured or killed by frost the danger seems to be over. We have never heard of a case where second-growth Kafir-corn fodder has injured stock.

OBJECTIONS TO KAFIR-CORN.

Like all sorghums, Kafir-corn makes a weak, slow early growth, which is in strong contrast to its vigor and hardiness after becoming a foot high. In damp ground, in wet seasons and on weedy land, the weeds in the early season will often make a strong growth while the Kafir-corn is too small to cultivate easily. This makes cultivation expensive and difficult.

When fed alone, stock tire of Kafir-corn much more quickly than they do of corn. Some stockmen feed red and white Kafir-corn alternately. This gives some variety, but only partially overcomes the defect. When Kafir-corn is fed with feeds rich in protein, as alfalfa, soy beans, bran, or oil-meal, animals relish it for any length of feeding period. Hogs fattened on Kafir-corn alone get so that they loathe it, but fed Kafir-corn with either alfalfa hay, soy beans, or skim-milk, they have a keen appetite for every feed.

This lack of protein (flesh- and blood-forming material) and an excess of starch and other heating substances makes Kafir-corn an undesirable feed to be given alone, but combined with the other drought-resisting feeds—alfalfa and soy beans—makes a ration containing all the material in proper proportions needed for meat and milk production and the growth of young stock.

Kafir-corn is a very constipating feed, and for this reason, when fed alone to either horses, cattle, or hogs, induces an unhealthful condition. Fed with other constipating feeds, such as prairie or timothy hays or corn-fodder, the condition is made worse. On the other hand, alfalfa and soy beans are laxative feeds, and either fed with Kafir-corn secures a healthful condition of the animal, as shown by the glossy hair, oily skin, good appetite, and good returns.

There is a general feeling all over Kansas among farmers who have raised but little Kafir-corn that it is very exhaustive to the soil, and they find that for a year or two after a good crop of Kafir-corn has been raised on a field that following crops are poor. This comes from wrong handling. We raise Kafir-corn every year on the College farm—sometimes for several years in succession on the same

field—and have not had following crops shortened by the Kafir-corn. We have in our office heads of Kafir-corn twelve to sixteen inches in length and well filled that were raised on thin upland that has been in Kafir-corn continuously for seven years. The yield per acre was heavy.

Kafir-corn is our great drought-resisting crop and will continue to extract water from a dry soil and grow long after corn has stopped growing. If a good soil mulch is not kept on the surface during such a time the ground on which Kafir-corn is growing will become hard and lumpy, this condition continuing through the growth of succeeding crops. We cultivate Kafir-corn to keep a good earth mulch on the surface, if necessary cultivating the last time with a five-toothed cultivator set shallow. This prevents the ground from becoming hard and giving reduced yields the following seasons. Kafir-corn removes practically the same plant-food from the soil that corn does, and is not more exhaustive than corn for the same yield, except in the manner indicated.

Kafir-corn will not mature in the extreme western part of the state. The high altitude there gives cool summer nights, retarding the growth, and frost kills the Kafir-corn before it is ripe. In sections of Kansas where this is the case, the near relatives of Kafir-corn, Jerusalem corn, and rice-corn, do mature, and, with fair treatment, yield from twenty-five to fifty bushels per acre. The grain of these crops has practically the same value as Kafir-corn, but the yield of fodder is much less and the fodder is less palatable.

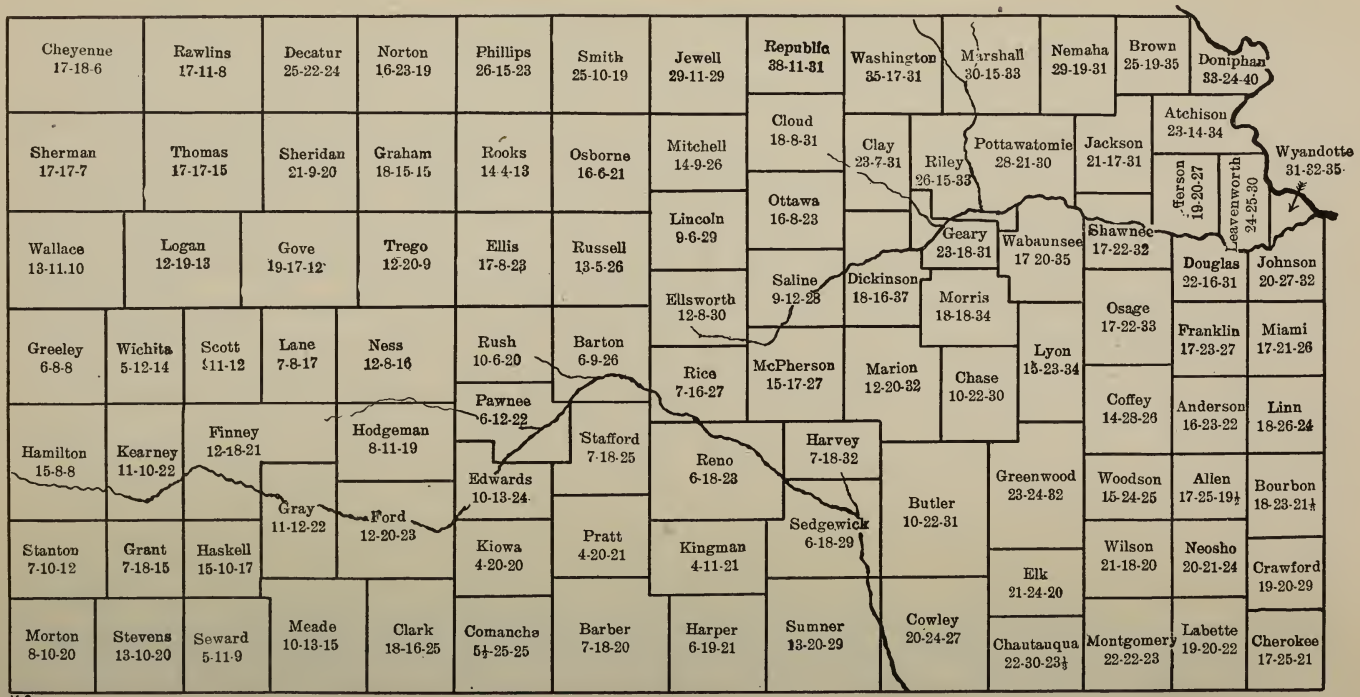
WHERE SHALL KAFIR-CORN BE GROWN?

We cannot take space in this bulletin to thoroughly discuss the facts shown by the maps, but it will pay the reader to make an exhaustive study for himself. The figures given in the maps were computed from tables published in Secretary Coburn's reports of the state board of agriculture and shows the yield of corn by counties.

Map. No. 1 shows the average yield of corn per acre in bushels for the years 1897, 1898, and 1899, the figures at the left being for 1897, those in the center for 1898, and those at the right for 1899; thus: $\overset{\text{Doniphan}}{33\text{–}24\text{–}40}$, indicates that the average yield of corn per acre in Doniphan county was 33 bushels in 1897, 24 bushels in 1898, and 40 bushels in 1899.

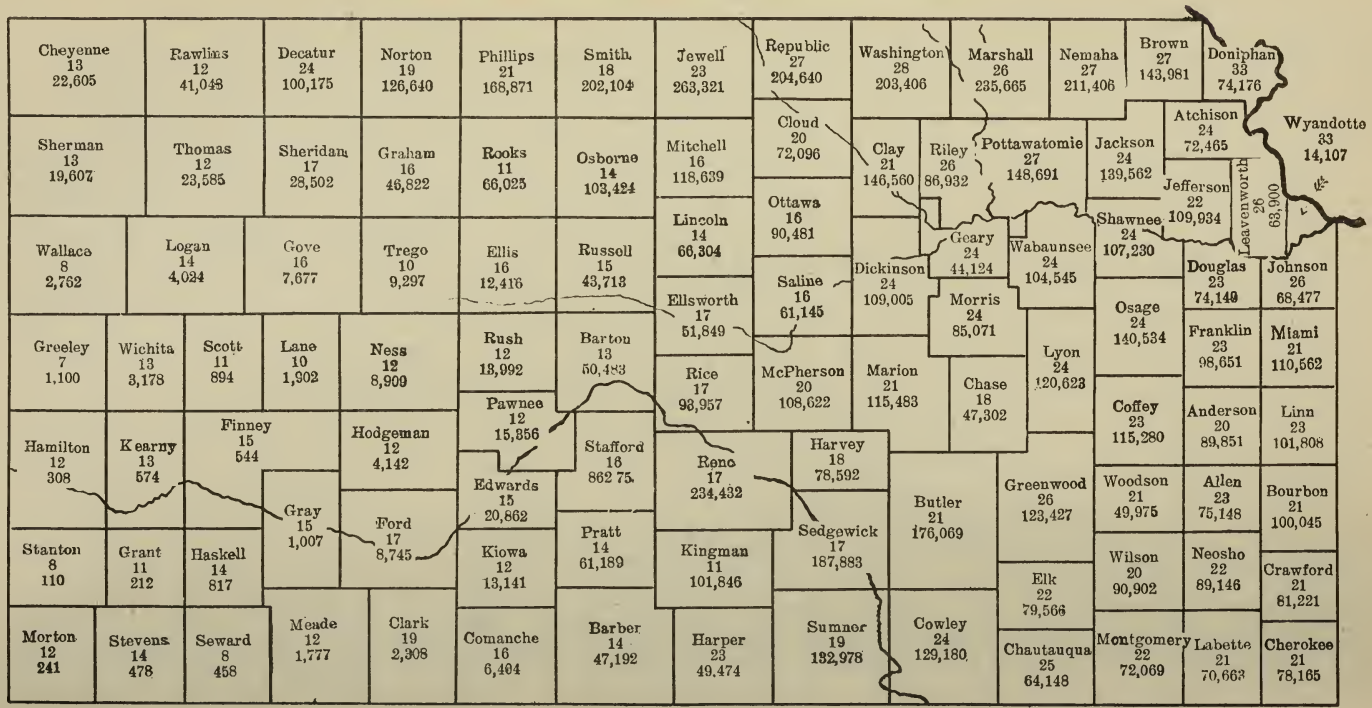
Map No. 2 shows the average yield of corn per acre in bushels for the three years—1897, 1898, and 1899—and the average number of acres grown per year for this period; thus: $\overset{\text{Riley}}{\underset{86{,}932}{26}}$ indicates that for the period mentioned the average yield of corn was 26 bushels per acre per year, and that an average per year of 86,932 acres were planted.

Kansas Corn Crop, 1897, 1898, and 1899.



MAP No. 1. Showing the average yield of corn per acre in bushels, the figures at the left being for **1897**, those in the center for **1898**, and those at the right for **1899**. See page 44.

Kansas Corn Crop, 1897, 1898, and 1899.



MAP No. 2. The upper line of figures shows the average yield of corn per year per acre, and the lower line the average yearly acreage in corn. See page 44.

It is safe to say that corn must average at least twenty bushels per acre or it will not pay to raise it. By reference to the maps, it will be seen that the east tier of counties all show a greater average than this for the three years. In these counties it is probable that it will not pay to raise Kafir-corn, except on thin lands. Take the tier of counties represented by Washington, Clay, Dickinson, Marion, Butler, and Cowley: the average yield per year for the three years is above twenty bushels for each county, but some years show low yields, Clay averaging seven bushels of corn per acre in 1898, Washington seventeen bushels in 1898, Dickinson eighteen bushels in 1897 and sixteen in 1898, Marion twelve bushels in 1897, and Butler ten bushels in 1897. In these counties Kafir-corn should be raised on all uplands, and will probably show an average yearly yield as great as that of the College farm—forty-six bushels per acre.

The tier of counties composed of Smith, Osborne, Russell, Barton, Stafford, Pratt and Barber shows an average yearly yield of less than twenty bushels of corn for every county, and it is probable that the farmers in these counties would get much greater returns in feeding if most of their corn lands were planted to Kafir-corn. We believe that the section of the state represented by these and adjoining counties will average as much beef, pork and milk per acre per year from Kafir-corn as will the eastern tier of counties from corn.

A study of the counties west of this last group shows strikingly the low yield of corn, and the advisability of planting Kafir-corn.

Kafir-corn stands drought much better than corn, and will draw more plant-foods out of tough, hard soils than will corn. For this reason, it will pay to raise it instead of corn on the uplands of eastern Kansas, where it will furnish feed that will produce more beef, more pork and more milk per acre than will corn. Corn will probably yield as much on bottom lands in eastern Kansas as Kafir-corn, and, bushel for bushel, is worth more to feed. In central Kansas, Kafir-corn is the best yielder on uplands, and often pays on the bottoms.

In many sections of western Kansas corn is not a paying crop in the most favorable season, while Kafir-corn will give a good yield almost every year, and enable these sections to become feeding districts for their own cattle and for cattle raised west and south of them. Where Kafir-corn will not mature plant Jerusalem and rice corns.

All remember what wonderful prosperity was open to Kansas in 1899, while we had a promise of 300 to 350 million bushels of corn, and how prosperous we are to-day, even though those three days of terrible hot winds in September cut the yield to 225 million bushels of corn. If the land now in corn in this state but not adapted to it,

but adapted to the better drought resister, Kafir-corn, should be planted to Kafir-corn, and this Kafir-corn should be fed with our other drought resisters, alfalfa and soy beans, every year in Kansas would show a meat production equal to a year producing 350 million bushels of corn.

EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN No. 94—APRIL 1900.

CHEMICAL AND GENERAL DEPARTMENTS.

CHEMICAL DEPARTMENT.

J. T. WILLARD, M. S., Chemist.
R. W. CLOTHIER, M. S., Assistant Chemist.

SUGAR BEETS, 1899.

THE work with sugar beets has been less satisfactory the past year than the two preceding, as but few samples were sent in for analysis. Fewer applications for seed were received, and the percentage of these who responded with samples for analysis in the fall was smaller. But for sake of completeness, a report might well be dispensed with. Our state is still interested in the sugar-beet question to a certain extent, however, and we feel that the chemical department of the Experiment Station is filling a real need in furnishing unbiased yet sympathetic service in the analysis of Kansas beets. We have always recognized that the agriculture of our state needs diversification; at the same time we have strenuously urged that attempts to establish the beet-sugar industry in our midst should not be hastily launched, but that a thorough agricultural and chemical investigation of the capacities of a given region should be made before investing capital largely. The lesson of the sorghum-sugar enterprises should not be forgotten in our zeal for new channels for investments.

Table Showing Analyses of Sugar Beets.

Serial No.	Name of grower.	Post-office.	County.	Date of planting.	Kind of soil.	Date of analysis.	No. beets.	Form of beets.	Average wt. in pounds.		Specific gravity of juice.	Total solids in juice.	Cane sugar in juice.	Purity of juice.	Serial No.
									Gross.	Net.					
13	J. A. Maddy	Fairhaven	Norton	May 8	Hillside, clay	Oct. 4	6	Medium	1.35	1.23	1.070	17.00	13.82	81.3	13
26	Frank Georgia	Mankato	Jewell	May 15	Black loam	Nov. 9	6	Medium		1.78	1.065	15.85	12.49	78.8	26
10	Joseph Decker	Rice	Cloud	May 15	Black sandy loam		6	a ir	1.70	1.49	1.055	13.52	10.49	77.6	10
33	Wm. Becker	Sylvan Grove	Lincoln	April 15	Sandy loam	Nov. 16	3	Fair	1.00	0.91	1.073	17.68	13.24	74.9	33
20	Chas. McGuire	Beverly	Lincoln	May 1	Dark loam	Oct. 30	6	Good	1.60	0.79	1.060	14.70	12.25	83.4	20
9	A. C. Hutchinson	Blue Rapids	Marshall,	May 5	Black prairie loam,		6	Good	1.60	1.30	1.060	14.70	12.25	83.4	9
39	S. S. Dickinson	Larned	Pawnee	May 23	Sandy loam	Dec. 2	6	Fair	1.08	0.86	1.056	13.76	10.29	74.8	39
11	W. O. Park	Netawaka	Jackson	May 2	Sandy loam	Oct. 19	6	Poor	1.36	0.55	1.056	13.76	11.45	83.2	11
4	J. W. Louthian	Huron	Atchison	May 9	Dark sandy	Oct. 18	10	Fair	1.50	1.10	1.061	14.93	12.02	80.5	4
19	L. B. Bell	Winchester	Jefferson,	May 10	Sandy loam	Oct. 30	6	Fair	0.84	0.67	1.070	17.00	14.46	85.1	19
12	Geo. B. Bell	Wakarusa	Shawnee	April —	Black loam	Oct. 21	6	Fair	1.40	1.07	1.050	12.35	8.78	71.1	12
24	Peter Carey	Burrton	Harvey	June 1	Black clay	Nov. 9	6	Good	1.46	1.34	1.078	18.81	14.11	75.0	24
27	Abraham Dick	Burrton	Harvey			Nov. 9	6	Medium	0.53	0.47	1.073	17.68	15.72	88.9	27
14	Wilbern Bush	Wichita Heights,	Sedgwick,	April 28	Sandy, dark	Oct. 24	10	Fair		1.66	1.060	14.70	10.66	72.5	14
21	Mrs. E. Smyser	Wichita Heights,	Sedgwick,	April 4	Black loam	Oct. 30	6	Medium	1.70	1.25	1.043	10.68	7.80	73.0	21
23	J. W. Farber	Mulvane	Sumner	May 5	Sandy loam	Nov. 6	6	Fair	1.20	0.95	1.058	14.23	9.67	68.0	23
22	Geo. A. Blair	Mulvane	Sumner	May 6	Sandy loam	Nov. 4	6	Fair	1.18	0.84	1.057	13.99	6.03	43.1	22
15	J. E. Throckmorton,	Mulvane	Sumner			Oct. 26	6	Medium	1.60	1.40	1.067	16.31	13.50	82.8	15
40	Isaac Hemphill	Vinland	Douglas	May 7	Timber soil	Dec. 4	12	Good		0.72	1.050	12.35	8.84	71.6	40
38	W. A. Pine	Lawrence	Douglas	May 5	Dark loam	Dec. 2	6	Good	1.38	1.40	1.063	15.39	12.05	78.3	38
25	B. B. Craig	Waverly	Coffey	May 1	Sandy	Nov. 9	6	Poor	1.57	1.20	1.045	11.16	7.45	66.8	25

16	Homer Brown	Arkansas City	Cowley	May 1	Black loam	Oct. 26	6	Fair	1.40	0.73	1.076	18.36	15.30	83.4	16
18	John Dozzeforet	Block	Miami	May 23	Black prairie loam,	Oct. 28	2	Poor	1.60	1.21	1.060	14.70	9.49	64.6	18
17	Andrew Listen	Block	Miami	May 2	Black prairie loam,	Oct. 28	2	Poor	1.60	0.97	1.040	9.97	4.33	43.4	17
5	E. D. Kramer	La Harpe	Allen	June 1			2	Poor	0.46	0.41	1.079	19.04	15.36	80.6	5
7	C. H. Bratt	Humboldt	Allen	June 5	Black loam		1	Fair	0.40	0.31	1.055	13.52	9.29	68.5	7
37	A. Nelson	La Harpe	Allen	June 1		Nov. 21	2	Medium	1.39	1.10	1.065	15.85	11.30	71.3	37
8	Wm. Overholt	Humboldt	Allen	June 5	Black loam		1	Fair	0.34	0.27	1.054	13.29	9.43	71.0	8
1	O. D. Conch	Fort Scott	Bourbon	June 1	Black loam	Oct. 14	1	Fair	0.32	0.26	1.067	16.31	13.18	80.8	1
2	Hiram Bulla	Uniontown	Bourbon	June 1	Black loam	Oct. 14	2	Fair	1.27	1.05	1.066	16.08	11.49	71.4	2
3	B. L. Wert	Fort Scott	Bourbon	June 5	Black loam	Oct. 14	2	Poor	0.77	0.48	1.061	14.93	11.34	76.1	3
6	R. Ewing	Godfrey	Bourbon	June 1	Black loam		2	Fair	2.34	1.87	1.050	12.35	8.63	69.6	6
35		Fort Scott	Bourbon			Nov. 20	3	Poor	0.98	0.83	1.040	9.97	4.50	45.2	35
32	R. Ewing	Godfrey	Bourbon	May 25	Black loam	Nov. 9	6	Medium	0.25	0.20	1.071	17.22	14.17	82.3	32
31	A. Hunley	Fort Scott	Bourbon	May 25	Black loam	Nov. 9	5	Medium	0.45	0.38	1.067	16.31	14.05	86.2	31
30	Wm. Heath	Fort Scott	Bourbon	May 25	Black loam	Nov. 9	5	Fair	1.09	0.93	1.061	14.93	12.05	80.7	30
29	— Bartam	Fort Scott	Bourbon	May 25	Black loam	Nov. 9	6	Medium	0.54	0.45	1.061	14.93	12.39	83.0	29
28	G. H. McComb	Fort Scott	Bourbon	May 25	Black loam	Nov. 9	6	Fair	0.79	0.63	1.061	14.93	12.39	83.0	28
34	H. A. Emes	Iantha, Mo.	Barton		Black loam	Nov. 20	3	Poor	0.79	0.69	1.037	9.24	4.57	48.4	34
36	R. R. Selves	Lamar, Mo.	Barton		Black loam	Nov. 20	4	Medium	0.64	0.53	1.037	9.24	4.95	53.6	36
	Averages								1.12	0.89	1.059	14.54	10.89	73.4	

The analyses made in 1899 are presented in the accompanying table. As last year, the counties are named in the order of their occurrence in belts from northeast to southwest, beginning at the northwest corner. These belts are approximately parallel to the isotherm of 70° F. for the months of June, July, and August. This temperature is believed to be the most favorable for the sugar beet. It lies entirely outside the state, but the counties by the arrangement chosen are named approximately in the order of their nearness to it.

The averages deduced from the table are presented below, and with them the corresponding figures for the two preceding years:

Comparison of Results Obtained.	1897.	1898.	1899.
Average gross weight, in pounds	1.51	1.45	1.13
Average net weight, in pounds	1.09	1.12	0.87
Average specific gravity of juice	1.064	1.06	1.059
Average total solids in the juice	15.52	14.71	14.54
Average percentage of sugar in the juice	11.88	11.56	10.89
Average coefficient of purity of the juice	76.10	77.80	73.40

The preceding summary affords but little encouragement to those who hope to establish the beet-sugar industry in our state. From the reports of growers, it should be said that the year seems to have been an unpropitious one in many localities, and a considerable number of the samples were remnants that had escaped from the floods, drought, insects or rabbits that destroyed the bulk of the stand. Under such circumstances good results cannot be expected. The reports also show that in but few instances was the culture and care such as it must be to insure the best results.

If we examine the details of the table, we find, as in former years, that excellent beets can be grown in the state, and it would seem that sufficient effort might result in the discovery of localities well adapted to their culture. Of the ten samples grown in the vicinity of Fort Scott, six showed over twelve per cent. of sugar in the juice.

In harmony with the wishes of the department of agriculture and the dictates of good judgment, a special effort was made to interest people in the culture of larger plats of the beets than most of them had previously, and forty-seven farmers at their own request were furnished with seed sufficient to plant one-fourth acre or more. This was with the understanding that the beets were to be cultivated as nearly as possible in accordance with the directions, and a more extensive record and report made upon the season, soil, etc., than was expected of others. Of these forty-seven but twelve sent in samples of beets for analysis. In some instances the crop was reported as destroyed, or a failure from circumstances beyond the control of the experimenter; but twenty-six never made any report whatever to the

Station. In the face of such conditions, it is evident that voluntary cooperation with the people of the state in an investigation will not be likely to be successful unless there is an immediate pecuniary interest in the case. The quality of the beets raised by those cultivating the larger plats was somewhat better than the average, they showing an average of 11.49 per cent. of sugar, and a coefficient of purity of 75.

CONCLUSION.

The results of the past three years confirm those of former years, and indicate that while Kansas has produced many individual plats of excellent quality she has produced more of inferior quality, and that states in higher latitudes are better situated for successful sugar-beet production. Doubtless with a better understanding of the conditions requisite to success, and a greater willingness to take the pains and make the necessary effort to meet these conditions, better beets can be grown. The state will always be at a disadvantage, however, and, with its superb adaptation to corn, wheat, alfalfa, and other staple crops, it is probably the part of wisdom to leave this one chiefly to other states, except as it is grown for feed.

However, the Station stands ready to assist all organizations within the state which desire to test its capabilities in this direction further, and will furnish seed this year to any group of farmers making application. Seed will be furnished only for the use of such groups of farmers. It is of the finest quality and is donated by the United States department of agriculture.

It seems proper to caution the public once more against hasty and ill-considered efforts to establish beet-sugar factories in this state, or indeed elsewhere. A thorough test of the beet-producing power of the locality, and the disposition of the farmers, should be made before a dollar is invested as fixed capital. The Station is ready to do its part in all such tests, with an eye single to the ultimate prosperity of the state.

Plans for 1900.

For the next season the Station will furnish sugar-beet seed only for the purpose of making thorough tests; hence, only to groups of farmers desiring to test given localities. To do this with any hope of satisfactory or conclusive results, the beets must be produced under the most favorable cultural conditions, as the limitations of our climate must be recognized as unfavorable. We have found no reason for modifying the directions adopted two years ago and include them in this bulletin. We also urge that the trial plats be not too small. With small plats the attacks of grasshoppers, rabbits, etc., are much more likely to result in total loss than when larger plats are employed. We also desire to especially urge early planting.

Directions for Growing Sugar Beets.

The following directions are based upon our own experience, combined with careful study of the methods in use for producing beets for sugar manufacture in Nebraska, Utah, and California. A correct judgment in regard to the adaptability of our state to the production of beets suitable for sugar making cannot be made unless the beets are grown under proper conditions. It is urgently requested, therefore, that these directions be closely followed.

Preparation of the Soil. If soil deeply plowed last fall, and suitable otherwise, is available, use that. It is necessary that the soil be readily penetrable by the growing beet to a depth of ten or twelve inches. If the soil has not hitherto been plowed to that depth, plow an inch or two deeper than before and loosen the subsoil in each furrow by a subsoil plow or a spade. Two rods square, well prepared, will be of more service than more improperly prepared. The soil must be in perfect tilth, well pulverized by repeated disking and harrowing, and as free of weed seeds as practicable. Soil that runs together and packs with rain is not suitable. Throughout the growth of the beet the soil must be permeable to the air, and this should be in mind in selecting it. The soil must not be handled when too wet or too dry; it should have been under cultivation at least two years, and must have no stable manure applied this spring.

Planting. Just previous to planting, the final harrowing of the soil should be given, so as to kill all weeds that may have started. It is well to roll the ground then. Plant by hand or with a seed-drill, in rows from sixteen to eighteen inches apart. The seed should not be covered deeper than one inch, and the soil above the seed must be well firmed by the press wheel of the drill or otherwise. Most failures to secure good germination are due to leaving the surface so loose as to dry out. Beet seed must be planted shallow, but must have moisture. If planted by hand, the seed may be dropped three or four together at the intervals desired for the beets. This almost insures an even stand. About twenty pounds of seed per acre is required in field planting. The time of planting varies with the latitude and the season, but should be about the same as early corn planting, so that the plants may be well grown before the summer droughts.

Thinning. When the beets have four leaves they must be thinned. If left more than a week longer the roots of the plants left are injured in pulling out the others. The distance apart that the plants should be left depends upon the richness of the soil—the richer the soil the closer they may be grown. Six to ten inches will include all

cases, and with most of our soils seven or eight inches is about right. It must be borne in mind that the mature beets are to be of about two pounds weight and that very large size is not desirable. Where the beets have been sown uniformly throughout the row, thinning is begun by "bunching" the plants by means of a narrow-bladed hoe, with which the beets are cut out entirely excepting bunches of three or four at the proper intervals for the mature beets. The bunches are thinned by hand, leaving the strongest plant, and at the same time pulling up any weeds near it.

Cultivation. In cultivation, the conditions to be met are perfect freedom from weeds, looseness of soil, and guarding against injury to the leaves or roots of the beets. If the ground becomes crusted by heavy rain before the beets are up, it should be hoed, following the marks left in firming the soil; otherwise a first shallow hoeing should be done as soon as the beets break through. A second hoeing must follow the thinning; this should be to a depth of three inches. Similar hoeings will be necessary later. The space between the rows may be cleaned with a suitable cultivator, but loosening the soil between the plants in the rows will require the hoe.

Irrigation. For such as are able to try the growth of beets by irrigation, a few words based upon information kindly furnished by Mr. George Austin, agricultural superintendent for the Utah Sugar Company, Lehi, Utah, may not be amiss. Beets should not be watered too freely. Let them suffer a few days before irrigating. The water must be applied by means of little furrows made by a six-inch furrower attached to the rear of the cultivator, taking care not to flood the ground. Unless the soil has considerable slope, or is very sandy, watering in alternate rows is sufficient. The second time, the water is run down the rows left without water the first time. Cultivate as soon as practicable after each irrigation, to a depth of five or six inches. Two to four irrigations are given during the season, in Utah, the last one three or four weeks before harvesting.

Taking and Forwarding Samples. Directions for this will be sent in due time to all taking part in this test, and the beets are to be left in the ground until such directions are received. Some of the beets will be called for early, others quite late. We expect to be able to furnish franked tags allowing free transmission of the samples by mail. Applications for seed to be used substantially as directed above will be filed as received, and seed sent as soon as possible. Be careful to write name and address very distinctly. Inquiries at any time will be gladly received and promptly attended to. Address all applications for seed and communications concerning the experiment to J. T. Willard, chemist of the Experiment Station, Manhattan, Kan.

GENERAL DEPARTMENT.

J. T. WILLARD, M. S., DIRECTOR.

THE STATION PUBLICATIONS.

THE publications of the Experiment Station include annual reports, bulletins, press bulletins, and monthly weather bulletins.

The first and second annual reports, in addition to financial and general statements, contained much matter that had been issued in the form of bulletins. This reprinting seemed an unnecessary expenditure of funds, and since 1889 the annual reports have contained no details of experiments, but simply statements in regard to the work of the year in general and in the several departments, and including the financial statements required by law. These annual reports, not being of general interest, therefore, are printed in small numbers and sent to libraries and officials only, except on special request.

The bulletins are the means of communicating the results of the Station work directly to the farmers. They are issued in the quantities judged necessary to meet the demand. All investigations are described in them when completed, and they are sent to all on our mailing lists, including all the newspapers of Kansas, as required by law.

The press bulletins are issued in limited numbers and sent to the papers, to certain state and county officers, and to a considerable number of public or semi-public institutions. Our hope is that through them farmers may learn something of the Station work, and be led to apply for the regular bulletins, and also that the local papers, by reprinting them, may give wider currency to the information they contain. It is suggested that any who appreciate the value of them can serve the community at large as well as themselves by using a little effort in inducing the papers to reprint them. They are short, readable, and popular, but, at the same time, accurate articles on subjects of current interest, and embodying observations and experiments of members of the Station staff. Extra copies are printed of some for use in answering inquiries.

The monthly weather bulletins are sent out the next day after the close of the month, to the same addresses as the press bulletins.

ANNOUNCEMENT.

The Experiment Station has in stock back numbers of many of its publications which contain matter that is still of interest and value.

We desire to put these out among the people, and, as many now on our list have not received them, it seems desirable to call their attention to this and invite them and others to make application for such as they desire. To facilitate these applications, a complete list of the publications to date is given herewith, those out of print being marked with a star. An index to the subjects of chief interest follows the list and may be made use of in applying for publications.

ANNUAL REPORTS.

First Annual Report, 1888.*

Financial statements, report of the Council, and reports of departments, including the following articles: Waste of Manure in Summering Manures in the Yard. Experiments in the Corn Field. Experiments with Wheat, including Bulletin No. 4. Forage Crops. The Milk and Butter Product as Influenced by Feeding. The Pressure of Ensilage on the Walls of the Silo. Relation of Rainfall to the Corn Crop. Shrinkage of Hay in the Mow. A Comparison of Varieties of Sorghum, including part of Bulletin No. 5. A Test of the Keeping Qualities of Sorghum. An Examination of Individual Stalks of Sorghum, with a View to Improving the Plant. A Trial of Fertilizers on Sorghum. A New Method of Milk Analysis for the Use of Dairymen. Spraying in the Apple Orchard. Observations upon Injurious Insects, including Bulletin No. 3. Trials of Varieties of Potatoes. Trials of Varieties of Peas. Trials of Varieties of Tomatoes. Sorghum Blight, including part of Bulletin No. 5. Hackberry Knot. Experiments in Fertilization of Varieties of Corn. Germination of Weed Seeds. The Fungous Parasites of Weeds.

Second Annual Report, 1889.

Financial statements, report of the Council, and reports of departments, including the following articles: Experiments with Corn, Wheat and Forage Crops, including Bulletin No. 7. Silos and Silage, including Bulletin No. 6. Pig-feeding Experiment, including Bulletin No. 9. Pigs from Mature and Immature Parents. Work upon Sorghum. Analysis of Feeding Stuffs. Composition of Corn at Different Stages of Growth. Ammonia and Nitric Acid in Atmospheric Waters. Comparative Trials of Garden Beans, of Peas, of Potatoes, of Tomatoes, Some Insects Injurious to the Bean. Loose Smuts of Cereals, including Bulletin No. 8. Crossing Varieties of Corn, First Year. Receptivity of Corn Silk.

Third Annual Report, 1890.

Financial statements, and a report of the Council, including outlines of Bulletins 10 to 19, with index, and a summary of work in progress.

Fourth Annual Report, 1891.

Financial statements, and a report of the Council, including outlines of Bulletins 20 to 32, with index, and summary of work in progress.

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*Out of print. (The annual reports for 1888 and 1889 contain the subject-matter of Bulletins Nos. 3 to 9, inclusive.)

Fifth Annual Report, 1892.

Financial statements, and a report of the Council, including outlines of Bulletins 33 to 37, with index, and summary of work in progress.

Sixth Annual Report, 1893.

Financial statements, and a report of the Council, including an account of work in progress, outlines of Bulletins 38 to 45, a meteorological summary for thirty-six years, and an index.

Seventh Annual Report, 1894.

Financial statements, and a report of the Council, containing outlines of Bul letins 46 to 48, statements concerning irrigation experiments and other work in progress, and an index.

Eighth Annual Report, 1895.

Financial statements, and a report of the Council, containing outlines of Bulletins 49 to 56, a summary upon irrigation and other work in progress, and an index.

Ninth Annual Report, 1896.

Financial statements, and a report of the Council, containing outlines of Bulletins 57 to 64, a summary concerning irrigation and other work in progress, and an index.

Tenth Annual Report (January 1 to June 30), 1897.

Financial statements for the fiscal year, and a report of the Council for six months, including outlines of Bulletins 65 to 74, summary of work in progress, and an index to the report and Bulletins 65 to 75.

Eleventh Annual Report, 1897-'98.

Financial statements, and a report of the Council, containing outlines of Bulletins 76 to 80, and a summary of the work of the year and in progress.

Twelfth Annual Report, 1898-'99.

Financial statements, and a report of the Council, including outlines of Bulletins 81 to 89, a list of press bulletins 1 to 46, issued during the year, a summary of work in progress, and an index.

BULLETINS.

	Date.	Subjects.
*No. 1	April, 1888	Organization, Equipment, and Aims.
*No. 2	April, 1888	Experience with Cultivated Grasses and Clovers.
*No. 3	June, 1888	Life-history of Two Orchard Pests.
*No. 4	September, 1888	Experiments with Wheat.
*No. 5	December, 1888	Sorghum, and Sorghum Blight.
*No. 6	July, 1889	Silos and Ensilage.
*No. 7	July, 1889	Experiments with Wheat.
*No. 8	October, 1889	Preliminary Report on Smut in Oats.

*Out of print. (The annual reports for 1888 and 1889 contain the subject-matter of Bulletins Nos. 3 to 9, inclusive.)

	Date.	Subjects.
*No. 9	December, 1889	Experiment in Pig Feeding.
No. 10	May, 1890	Notes on Conifers for Kansas Planters.
No. 11	July, 1890	Experiments with Wheat.
No. 12	August, 1890	Preliminary Experiments with Fungicides for Stinking Smut of Wheat.
No. 13	August, 1890	Experiments with Oats.
No. 14	December, 1890	Winter Protection of Peach Trees, and Notes on Grapes.
No. 15	December, 1890	Additional Experiments and Observations on Oat Smut.
No. 16	December, 1890	Experiments with Sorghum and Sugar Beets.
No. 17	December, 1890	Crossed Varieties of Corn, Second and Third Years.
No. 18	December, 1890	Experiments with Forage Plants.
No. 19	December, 1890	Germination of Weeviled Peas. Garden Notes on Potatoes, Beans, and Cabbage.
No. 20	July, 1891	Wheat.
No. 21	August, 1891	Stinking Smut of Wheat.
*No. 22	August, 1891	Smut of Oats; Smut and Rust of Wheat.
No. 23	August, 1891	Smut of Sorghum and Corn.
No. 24	September, 1891	Staggers of Horses.
*No. 25	December, 1891	Sorghum for Sugar.
No. 26	December, 1891	Varieties of the Strawberry.
No. 27	December, 1891	Crossed Varieties of Corn.
No. 28	December, 1891	The Experimental Vineyard.
No. 29	December, 1891	Oats.
*No. 30	December, 1891	Corn.
No. 31	December, 1891	Sugar Beets.
*No. 32	December, 1891	Feeding Stuffs, and the Development of Grain Crops. Soy Beans.
*No. 33	August, 1892	Experiment with Wheat.
*No. 34	September, 1892	Experiments in Feeding Steers.
*No. 35	December, 1892	*Actinomycosis bovis*, or "Lumpy Jaw" of Cattle. Some Observations upon Loco.
*No. 36	December, 1892	Experiments with Sorghum and with Sugar Beets.
No. 37	December, 1892	Experiments in Potato Culture.
No. 38	March, 1893	Preliminary Report on Rusts of Grain.
No. 39	August, 1893	Experiments in Feeding Steers, II.
No. 40	August, 1893	Experiments in Wheat.
No. 41	December, 1893	Effect of Fungicides upon the Germination of Corn.
No. 42	December, 1893	Experiment with Oats.
No. 43	December, 1893	Experiments with Sorghum and Sugar Beets.
No. 44	December, 1893	Further Study of Native Grapes.
No. 45	December, 1893	Experiments with Corn.
No. 46	May, 1894	Rusts of Grain, II.
No. 47	August, 1894	Experiments with Wheat. Experiments in Feeding Steers, III.
No. 48	December, 1894	Six Years' Experience with Ensilage. Some Forage Plants. Renovating a Prairie Pasture.
No. 49	May, 1895	Cattle Poisoning by Potassium Nitrate. Mastitis.
No. 50	June, 1895	Kansas Weeds, I—Seedlings.

	Date.	Subjects.
No. 51	June, 1895	Steer Feeding, IV—A Comparison between Pure-bred Shorthorns and Scrubs.
No. 52	September, 1895	Kansas Weeds—Preliminary Circular on Distribution.
No. 53	October, 1895	Pig-feeding Experiments with Corn, Wheat, Kafir-corn, and Cottonseed.
No. 54	December, 1895	Experiments with Oats.
No. 55	December, 1895	Small Fruits by Irrigation. Culture of Strawberries.
No. 56	December, 1895	Experiments with Corn. Experiments with Kafir-corn.
No. 57	June, 1896	Kansas Weeds, III—Descriptive List.
No. 58	June, 1896	Cornstalk Disease of Cattle.
No. 59	August, 1896	Experiments with Wheat.
No. 60	September, 1896	Steer-feeding Experiments, Series V.
No. 61	November, 1896	Kafir-corn, Corn and Soy Bean Meal for Pigs. Kafir-corn and Corn-meal for Cattle.
No. 62	December, 1896	Corn-smut.
No. 63	December, 1896	Experiments with Oats.
No. 64	March, 1897	Experiments with Corn.
No. 65	May, 1897	Grafting the Apple.
No. 66	June, 1897	Kansas Weeds, IV—Fruits and Seeds.
No. 67	June, 1897	Steer Feeding, VI.
No. 68	June, 1897	Soil Moisture.
No. 69	June, 1897	Some Diseases of Cattle.
No. 70	July, 1897	Vegetable Growing.
No. 71	July, 1897	Experiments with Wheat.
No. 72	July, 1897	Growth of Young Stock.
No. 73	July, 1897	Miscellaneous Fruit Notes.
No. 74	July, 1897	Experiments with Oats.
No. 75	August, 1897	Root Development of Forage Plants.
No. 76	February, 1898	Kansas Weeds, V—Vegetative Propagation.
No. 77	March, 1898	Some Insects Injurious to the Orchard.
*No. 78	April, 1898	Sugar Beets.
No. 79	April, 1898	Bovine Tuberculosis.
No. 80	June, 1898	Kansas Weeds, VI—Distribution and Other Notes.
No. 81	September, 1898	Feed and Care of the Dairy Cow.
*No. 82	January, 1899	The Potato-stalk Weevil.
No. 83	April, 1899	Sugar Beets.
No. 84	April, 1899	Cold Storage for Fruit.
No. 85	April, 1899	The Growth of Alfalfa in Kansas.
*No. 86	June, 1899	Press Bulletins Nos. 1 to 34.
No. 87	April, 1899	Native Agricultural Grasses of Kansas.
*No. 88	May, 1899	Keeping Milk in Summer.
No. 89	June, 1899	Soil Moisture.
No. 90	January, 1900	Alfalfa in Eastern Kansas.
No. 91	February, 1900	Swine-plague.
No. 92	March, 1900	A New Drought-resisting Crop—Soy Beans.
No. 93	March, 1900	Kafir-corn.
No. 94	April, 1900	Sugar Beets, 1899. The Station Publications. Partial Index to Station Publications.

PRESS BULLETINS.

No.	Title.	Department issuing.
1.	Wheat Experiments	Farm.
2.	Keeping Milk in Hot Weather	Farm.
3.	The Fringed-wing Apple-bud Moth	Horticulture and Entomology.
4.	Soil Moisture and Soil Stirring	Chemical.
5.	Blackleg*	Veterinary.
6.	The Sand Plum	Horticulture and Entomology.
7.	Kafir-corn for Fattening Pigs*	Farm.
8.	Some Reasons why Fruit Does not Set	Botanical.
9.	The Peach Twig-borer*	Horticulture and Entomology.
10.	Fall Preparation for Alfalfa Seeding*	Farm.
11.	Celery*	Horticulture and Entomology.
12.	The Balanced Ration	Farm.
13.	Seed Breeding	Botanical.
14.	The Fruit-tree Bark-beetle	Horticulture and Entomology.
15.	Kansas Sugar Beets for 1898	Chemical.
16.	*Actinomycosis* (Lump-jaw, Big-jaw)	Veterinary.
17.	Hardy Ornamental Shrubs	Horticulture and Entomology.
18.	Notes on Weeds	Botanical.
19.	The Potato-stalk Weevil	Horticulture and Entomology.
20.	Possibilities in Corn Improvement	Chemical.
21.	Winter Protection of Peach Buds	Horticulture and Entomology.
22.	Grazing Grasses of Western Kansas	Botanical.
23.	The Spring Canker-worm	Horticulture and Entomology.
24.	A New Crop for Kansas Farmers (Soy Beans)	Farm.
25.	Alfalfa Hay for Fattening Hogs	Farm.
26.	*Tænia fimbriata* (Fringed Tapeworm)*	Veterinary.
27.	Sugar Beet Experiments for 1899*	Chemical.
28.	Treatment of Winter-injured Trees	Horticulture and Entomology.
29.	Milking Scrub Cows	Farm.
30.	Lice on Animals*	Veterinary.
31.	Potato Scab	Botanical.
32.	Blackleg (A)*	Veterinary.
33.	Blackleg (B)*	Veterinary.
34.	Get Ready for the Drought	Farm.
35.	Dysentery in Calves and Other Young Animals	Veterinary.
36.	Experiments with Swine-plague or Hog-cholera	Veterinary.
37.	Kafir-corn, Alfalfa Hay and Soy Beans for Pork*	Farm.
38.	What is a Digestion Experiment?	Chemical.
39.	Skim-milk Calves	Farm.
40.	Orchard Cultivation*	Horticulture and Entomology.
41.	Digestion Experiment with Alfalfa Hay	Chemical.
42.	To Rid the House of Flies	Horticulture and Entomology.
43.	Selection of Seed Wheat	Botanical.
44.	The Profitable Strawberry Bed	Horticulture and Entomology.
45.	Early Plowing and Moisture Conservation	Chemical.

No.	Title.	Department issuing.
46.	Soy Beans	Farm.
47.	Awnless Brome Grass	Botanical.
48.	The Kansas Experiment Station	General.
49.	A Horn-fly Trap Experiment	Entomological.
50.	Infectious Abortion in Cattle	Veterinary.
51.	Alfalfa in Eastern Kansas	Farm.
52.	Some Nitrogenous Forage Plants	Botanical.
53.	Experiments with Sugar Beets in 1899 and 1900	Chemical.
54.	Kafir-corn	Farm.
55.	Plant Breeding by Bud Selection*	Botanical.
56.	Digestion Experiments with Kafir-corn Stover and Kafir-corn Meal	Chemical.
57.	Protective Inoculation Against Blackleg in Cattle	Veterinary.
58.	Questions About Forage Plants	Botanical.
59.	How to Test the Vitality of Garden Seeds	Botanical.
60.	Gophers and Crab-grass *versus* Alfalfa	Farm.
61.	Salsify, or Oyster Plant	Horticultural.
62.	Tame Grasses for Kansas	Farm.
63.	Bromus Inermis	Farm.
64.	Prevention of Grain Smuts	Botanical.
65.	Horn-fly Remedies	Entomological.
66.	Causes of Failure in Spraying	Horticultural.

Partial Index to Station Publications to April 1, 1900.

The following index is an outgrowth of the needs of this office in sending out publications in response to requests for information upon the various lines of our investigations. It is hoped that its publication here will be found a convenience to those making application for bulletins as well as those who have preserved files of them. It presents in concise form the range of work that the Station has touched. It refers in one way or another to every bulletin and press bulletin, and to the articles in the first two annual reports. Many of these references are given under general heads only. The index does not profess to refer to the many individual species of plants, insects, etc., that have been under experiment or observation, and, in fact, details are included in respect to the most important subjects only. The intention has been to make the references complete for the topics as named, and it is believed that no important omissions can have occurred, but it is too much to hope that there are no minor ones.

EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN No. 95—APRIL 1900.

FARM DEPARTMENT.

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D. H. OTIS, M. S., Assistant in Dairying.
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FATTENING HOGS WITH DROUGHT-RESISTING CROPS.

THIS bulletin gives the results of feeding experiments made with 326 hogs. Eight experiments were made; the first was begun November 15, 1897, and the last completed January 8, 1900. The object of the work was to develop the best methods of feeding hogs the Kansas crops that are good drought resisters and that do well on upland. We wanted to develop methods of handling these feeds that would produce the greatest daily gain for hogs at least cost, the greatest weight of pork per acre of feed, and pork of the best quality for the table.

Prof. F. C. Burtis, now of the Oklahoma Experiment Station, assisted in the experiments of 1897 and 1898.

In the first experiments ordinary methods were used. A careful study of the feeding indicated that certain changes would probably secure better results. These changes were made in the following experiment, and these in turn suggested further changes. In each of the latter experiments, the experience gained in those preceding it was used to improve the methods employed. This explains the lack of uniformity in the eight trials.

The different lots in each experiment were selected to make their average weights as nearly alike as possible and to have as nearly as we could judge the same feeding capacity. The same number of barrows were put in each of the lots of an experiment. If we had a "chunky" hog in one lot, a "chunky" hog was put in each of the other lots. If a long, rangy hog was in one lot, a hog of similar build was put in each of the other lots. The aim was to make the different lots in each trial so nearly unform that all variations shown in the gains would be due to feed only.

In each experiment each hog was weighed separately at the same hour three consecutive days, at the beginning of the experiment, and the average of the three weights taken as the weight of the hog. Each hog was weighed weekly during the experiment, and at the close of the experiment each hog was weighed three consecutive days, at the same hour each day that he was weighed at the beginning, and the average of these three weights taken as his weight at the close of the experiment. These precautions were taken to avoid variations in weight caused by different amounts of feed or water consumed that might have been shown from single-day weighings.

In all experiments the hogs were fed twice a day. Each feed was weighed and the hogs were given what they would eat clean within an hour after feeding. Salt, wood ashes and charcoal made from corn-cobs were kept in boxes where the hogs could eat them at will.

In the second experiment the hogs were fed in closed sheds; in the

PLATE I. Summer and winter sheds and yards.

other experiments the hogs fed in winter were sheltered by sheds open to the south and the troughs were not under shelter. We wanted shelter that would not be better than that on the average farm. The hogs fed in summer had low sheds built without sides. The cut shows both winter and summer sheds and method of feeding.

FIRST EXPERIMENT.

Thirty hogs were used in this experiment. They were all bred by the College, born in the spring of 1897, about seven and one-half months old at the beginning of the experiment, and were pure-bred Berkshires and Poland-Chinas. The experiment began November 15, 1897, and continued forty-nine days. The table explains the feed used for each lot, the weight of hogs and feed, and the gains.

Lot No.	I. Feed.	Hogs in lot.	Average weight per head, pounds.		Gain, pounds.		Grain fed, pounds.			
			Beginning	Close.	Average daily gain per head	Average total gain per head	Total pounds.	Per day per head	Pounds gain per bushel of grain	Feed for 100 lbs. gain
1	Kafir-corn whole, dry	5	188.0	256.0	1.39	68.0	1,846	7.53	10.33	**542**
2	Kafir-corn whole, soaked forty-eight hours	5	188.0	254.0	1.35	66.0	2,090	8.53	8.86	**632**
3	Kafir-corn meal, wet	5	187.6	278.2	1.85	90.6	2,136	8.72	11.89	**471**
4	Corn shelled, dry	5	188.2	261.8	1.50	73.6	1,678	6.85	12.25	**457**
5	Kafir-corn meal one-half, corn-meal one-half, wet	5	188.2	281.8	1.91	93.6	2,136	8.72	12.28	**456**
6	Kafir-corn meal four-fifths, soy-bean meal one-fifth, wet	5	188.2	292.0	2.12	103.8	2,122	8.66	13.89	**409**

Weight per bushel: Corn, 56 lbs.; Kafir-corn, 56 lbs.; soy beans, 60 lbs.

In this trial 457 pounds of dry corn, or 542 pounds of dry Kafir-corn, were required for 100 pounds of gain, Kafir-corn showing a feeding value equal to eighty-four per cent. of that of corn.

Equal parts of corn and Kafir-corn meal gave as good results as shelled corn alone. If this proves to be generally true, a farmer can raise corn on his bottom land and Kafir-corn on his upland, and by feeding the two mixed secure as good returns from his upland as from the bottoms.

Wetting Kafir-corn meal at the time of feeding gave best results, this method giving the meal a feeding value of ninety-seven per cent. of that of dry corn. Taking dry whole Kafir-corn as a basis, we saved thirteen per cent. by grinding and feeding wet, and lost sixteen per cent. by soaking forty-eight hours. This is the only trial made that showed a gain from grinding.

The value of adding soy beans to Kafir-corn is shown in this trial

as well as in all our other trials. The hogs having one-fifth their grain soy beans made a greater daily gain and more gain from each bushel of feed eaten. By feeding one-fifth soy beans with the Kafir-corn, a saving was made in the amount of feed required to make 100 pounds of gain of thirteen per cent. when compared with Kafir-corn meal wet, of twenty-four per cent. when compared with whole Kafir-corn dry, and of ten per cent. when compared with dry shelled corn. The hogs having soy beans were better finished at the close of the experiment and had that smooth, slick appearance shown by animals fed oil-meal.

SECOND EXPERIMENT.

Eighteen hogs were used in this trial. They were bred by the College, born in the spring of 1897, were about six months old at the beginning of the experiment, and were pure-bred Berkshires and Poland-Chinas. The experiment began November 22, 1897, and continued eighty-four days.

Lot No....	II. Feed.	Hogs in lot.....	Average weight per head, pounds.		Gain, pounds.		Grain fed, pounds.			
			Beginning....	Close.....	Average daily gain per head.....	Average total gain per head.....	Total pounds.	Per day per head.....	Pounds gain per bushel of grain...	Feed for 100 lbs. gain....
7	Kafir-corn whole, dry.....	3	124.0	256.0	1.18	132.0	2,030	8.05	10.93	**512**
8	Kafir-corn whole, soaked forty-eight hours	3	123.3	241.0	1.05	117.66	1,939	5.77	10.18	**550**
9	Kafir-corn meal, wet.....	3	124.0	226.0	1.21	102.0	1,704	6.76	10.01	**559**
10	Corn shelled, dry.....	3	123.3	225.3	1.21	102.0	1,462	5.80	11.69	**479**
11	Kafir-corn meal one-half, corn-meal one-half, wet..	3	121.66	245.66	1.48	124.0	1,780	7.06	11.74	**477**
12	Kafir-corn meal four-fifths, soy-bean meal one-fifth, wet.....	3	120.0	265.66	1.73	145.66	1,780	7.06	13.92	**408**

In this experiment the same methods of feeding were used as in the first trial, but the hogs were lighter and the fattening period was longer. In this trial whole Kafir-corn fed dry showed a feeding value equal to 93½ per cent. of that shown by shelled corn fed dry. A loss was shown both from grinding and from soaking Kafir-corn. Corn and Kafir-corn meals mixed in equal parts gave as good gains as shelled corn, and the hogs fed one-fifth soy-bean meal made the best daily gains and the most gains per bushel of feed eaten. The saving made in the amount of feed required to make 100 pounds of gain by feeding one-fifth soy beans with Kafir-corn meal was nearly fifteen per cent. when compared with dry shelled corn, and twenty-seven per cent. when compared with Kafir-corn fed wet.

THIRD EXPERIMENT.

Young Pigs.—Twenty pigs were used in this experiment. They were pure-bred Berkshires and Poland-Chinas, bred by the College. At the beginning of the experiment the oldest was eleven weeks and the youngest seven weeks of age. The pigs were weaned two weeks before the beginning of the experiment. The trial began November 22, 1897, and continued 112 days. The four lots ran together during the day on alfalfa pasture and were divided and shut in separate pens at night. The alfalfa had a fine young growth and furnished good pasture for nearly two weeks. December 2 a snow covered the ground, and thereafter the pigs could get but little picking from the alfalfa, but were turned into the field on nice warm days during the winter for exercise. The table shows feeds and gains, disregarding the pasture.

Lot No....	III. Feed.	Hogs in lot.....	Average weight per head, pounds.		Gain, pounds.		Grain fed, pounds.			
			Beginning	Close	Average daily gain per head.....	Average total gain per head.....	Total pounds.	Per day per head.....	Pounds gain per bushel of grain....	Feed for 100 lbs. gain....
13	Kafir-corn meal soaked forty-eight hours	5	35.8	110.0	.66	74.2	2,003	3.58	10.33	542
14	Kafir-corn meal two-thirds. soy-bean meal one-third, soaked forty-eight hours,	5	35.0	164.2	1.15	129.2	2,406	4.30	15.33	374
15	Corn-meal soaked forty-eight hours	5	35.6	118.2	.74	82.6	2,003	3.58	11.57	484
16	Corn-meal two-thirds, soy-bean meal one-third, soaked forty-eight hours,	5	34.4	154.8	1.08	120.4	2,229	3.98	15.54	369

The pigs were six months old at the close of the experiment and were sold for light pork. Neither Kafir-corn meal alone nor corn-meal alone gave satisfactory gains. In this respect the experiment simply confirms the judgment of our best feeders. Corn and Kafir-corn are good feeds for fattening mature hogs, but young pigs fattened while growing must have material in their food that will develop muscle, bone, and blood. Soy beans supply this material in abundance, while corn and Kafir-corn are deficient in it.

This experiment brings out strongly the value of soy beans for feeding young pigs. Nearly the same gains per hundred pounds of feed were made with Kafir-corn and soy beans as with corn and soy beans, while the pigs fed Kafir-corn and soy beans ate the most feed and made the greatest total gains. Making the grain ration of these young pigs one-third soy-bean meal saved nearly twenty-four per cent. with corn-meal, and thirty-one per cent. with Kafir-corn meal

in the amount of feed required for 100 pounds of gain over that needed with corn and Kafir-corn alone.

Experiments made after this trial was completed indicate that we probably lost by soaking the feed.

FOURTH EXPERIMENT.

Sixty hogs were used in this experiment; they were bought of farmers, and were good, thrifty hogs of mixed breeding, most of them cross-bred Berkshire and Poland-China, fairly representing the average hogs on Kansas farms.

Many farmers in the alfalfa sections of northwestern Kansas winter their stock hogs on alfalfa hay and a small grain ration, and a few feed alfalfa hay alone. This shows that alfalfa hay is a valuable feed for stock hogs, and we determined to test its value in fattening.

The alfalfa hay used in this experiment was of the best quality—fourth cutting, and well cured with all the leaves on. The whole alfalfa hay was fed dry in forkfuls, in shallow, flat boxes. The pigs were given more than they would eat, and they ate the leaves and finer stems, rejecting the coarser stems. The weight of hay given in the table is the weight fed, as the waste was not weighed. The alfalfa meal was made by grinding the hay in a Bowsher No. 8 iron feed-mill. This ground the leaves as fine as flour, but left some of the coarser stems only broken, the whole mass resembling bran in coarseness.

This experiment began November 24, 1898, and continued sixty-three days.

Lot No.	IV. Feed.	Hogs in lot	Average weight per head, pounds.		Gain, pounds.		Grain fed, pounds.			Pounds feed for 100 pounds gain.	
			Beginning	Close	Average daily gain per head	Average total gain per head	Total pounds.	Per day per head	Pounds gain per bushel of grain	Grain	Hay
17	Kafir-corn meal dry and whole alfalfa hay,	10	126.6	217.5	1.44	90.9	4,679	7.43	10.88	**515**	**72.4**
18	Kafir-corn meal dry and ground alfalfa hay	10	126.6	209.9	1.32	83.3	4,479	7.11	10.42	**538**	**78.7**
19	Kafir-corn meal four-fifths, soy-bean meal one-fifth	10	126.8	224.6	1.55	97.8	4,578	7.27	12.12	**468**	.....
20	Kafir-corn whole, dry.	10	125.9	185.2	.94	59.3	3,885	6.17	8.55	**655**	.....
21	Kafir-corn meal dry	10	125.5	177.9	.83	52.4	3,925	6.23	7.48	**749**	.....
22	Kafir-corn meal wet	10	125.0	188.3	1 00	63.3	4,375	6.94	8.10	**691**	

We were surprised at the results obtained in this experiment. We expected an increased gain from the hogs fed alfalfa hay, but not the

great increase shown. We expected that the ground alfalfa would produce greater gains than alfalfa fed whole; it gave less returns.

The hogs fed Kafir-corn meal and whole alfalfa hay gained an average of 90.9 pounds each in nine weeks, while those having Kafir-corn meal alone gained an average of 52.4 pounds each, an increase of over seventy-three per cent. from feeding the hay. The hogs fed hay ate more grain and gained more for each bushel eaten. The gains per bushel of feed were:

Kafir-corn meal dry and 7.83 pounds alfalfa hay	10.88 lbs.
Kafir-corn meal dry alone	7.48 "

This shows a gain from the hogs of 868 pounds per ton of alfalfa hay fed. With hogs at three cents per pound live weight, the hay fed the hogs made a return of $26.04 per ton; and with hogs at four cents per pound live weight, the hay returned $34.72 per ton. These results are not due to the feeding value of the alfalfa alone, but also to its influence in aiding the hogs to better digest the Kafir-corn. The alfalfa also gave variety to the ration, making it more appetizing and inducing the hogs to eat more grain.

Wetting the Kafir-corn meal made a saving of nearly eight per cent. over feeding it dry, while grinding the Kafir-corn caused a loss of over fourteen per cent.

Soy-bean meal produced even better results than the alfalfa hay. The hogs fed Kafir-corn meal four-fifths, soy-bean meal one-fifth, gained 97.8 pounds, while those fed on Kafir-corn meal alone gained 52.4 pounds, an increase of over 86½ per cent. from feeding the beans. The hogs fed the soy-bean meal required 468 pounds of grain for 100 pounds of gain, while those having Kafir-corn meal alone required 749 pounds of grain, a saving of over thirty-seven per cent. in amount of feed needed.

After nine weeks' feeding, it was evident that it would not pay to continue the experiment longer; the hogs ready for market were sold, while those not in marketable condition were kept to be fed in the fifth experiment. The hogs in the different lots showed great differences in finish, as follows:

Lot 17.—Kafir-corn meal dry and whole alfalfa hay. All in marketable condition.

Lot 18.—Kafir-corn meal dry and ground alfalfa hay. All in fair condition. Three retained because they could be fed longer profitably.

Lot 19.—Kafir-corn meal four-fifths, soy-bean meal one-fifth. All in good condition, and having the best finish of any lot. Two were kept for longer feeding.

Lot 20.—Kafir-corn whole, dry. Four in good flesh, and sold; six lank and not filled out, but thrifty in appearance.

Lot 21.—Kafir-corn meal dry. Four in good condition, and sold; six retained; two of these looked rough, and had made little gain. They did not relish the feed.

Lot 22.—Kafir-corn meal wet. Five in good condition, and sold; five were thrifty-looking, but too thin to market.

FIFTH EXPERIMENT.

Eighteen of the hogs retained from the previous experiment were selected for this trial, the selection being made to get three lots even in condition and feeding ability.

The Kafir-corn meal for lot 23 was wet with water at the time of feeding, and the alfalfa hay was fed whole in a shallow, flat trough. The cottonseed-meal was mixed with the Kafir-corn for lot 24, and the mixture wet with water at the time of feeding. The skim-milk fed lot 25 was poured over the Kafir-corn meal at feeding.

This experiment began February 2, 1899, and continued twenty-two days, when all the hogs were in marketable condition.

Lot No....	V. Feed.	Hogs in lot.....	Average weight per head, pounds.		Gain, pounds.		Grain fed, pounds.			Pounds feed for 100 lbs. gain.	
			Beginning	Close	Average daily gain per head.....	Average total gain per head.....	Total pounds.	Per day per head.....	Pounds gain per bushel of grain.....	Kafir-corn grain ...	
23	Kafir-corn meal wet and alfalfa hay whole	6	164.3	183.8	.88	19.5	629	4.76	10.4	538	Hay 214.0
24	Kafir-corn meal and cottonseed-meal wet	6	160.5	181.5	.95	21.0	681*	5.16	10.4	466	Cottonseed 73.8
25	Kafir-corn meal and skim-milk.	6	171.0	224.5	2.43	52.5	861	6.52	20.9	268	Milk 526.0

*Kafir-corn meal, 588 lbs., cottonseed-meal, 93 lbs.; or 1 lb. Kafir-corn to .16 lb. cottonseed-meal.

The experiment was conducted during the coldest days of the year, the thermometer registering 32 degrees below zero February 12. Notwithstanding the intense cold, the hogs fed alfalfa hay and those fed cottonseed-meal fattened into good condition and the hogs fed skim-milk made large gains. The hogs fed skim-milk were fatter then the average hogs marketed.

This experiment particularly shows the value of skim-milk in reducing the cost of producing pork. At the time of the trial, the prices of feed at Manhattan were: Kafir-corn meal, 55 cents per 100 pounds;

alfalfa hay, $6 per ton; cottonseed-meal, $20 per ton, and skim-milk, 15 cents per 100 pounds. At these prices for feed, the cost of 100 pounds of gain was, for the hogs fed alfalfa hay, $3.60; for the hogs fed cottonseed-meal, $3.30; and for the hogs fed skim-milk, $2.26.

SIXTH EXPERIMENT.

Fifty hogs were used in this experiment, and the plan was to show more fully the value of the best methods used in previous trials. The hogs were bought of farmers, were below the average Kansas hog in quality, and not equal to those used in previous experiments. All grain in this experiment was wet with water at the time of feeding, as this method had given best returns in previous trials. The Kafir-corn and soy-bean meals were ground medium fine in a Bowsher No. 8 iron feed-mill. The alfalfa had been cut too late, was rather woody, and many of the leaves were gone. It was the best we could get at the time of trial.

This experiment began February 28, 1899, and continued for fifty days.

Lot No....	VI. Feed.	Hogs in lot.....	Average weight per head, pounds.		Gain, pounds.		Grain fed, pounds.			Lbs. feed for 100 lbs. gain.	
			Beginning.....	Close.....	Average daily gain per head.....	Average total gain per head.....	Total pounds.	Per day per head.....	Pounds gain per bushel of grain....	Grain.....	Hay.....
26	Kafir-corn whole and alfalfa hay.....	10	141.6	210.1	1.37	68.5	3,434	6.87	11.18	**501**	**131**
27	Kafir-corn meal and alfalfa hay.....	10	139.9	208.5	1.37	68.6	3,535	7.07	10.85	**516**	**123**
28	Kafir-corn meal four-fifths, soy-bean meal one-fifth.....	10	142.6	229.2	1.73	86.6	3,766	7.53	13.04	**435**	.....
29	Kafir-corn whole.....	10	138.2	183.8	.91	45.6	2,910	5.82	8.75	**640**	.....
30	Kafir-corn meal.....	10	138.8	182.9	.88	44.1	2,872	5.75	8.59	**653**	.....

The gains per hog in fifty days from the different methods of feeding were as follows:

Kafir-corn whole and alfalfa hay..... 68.5 lbs.
Kafir-corn meal and alfalfa hay..... 68.6 "
Kafir-corn whole, alone..... 45.6 "
Kafir-corn meal alone..... 44.1 "
Kafir-corn meal four-fifths, soy-bean meal one-fifth..... 86.6 "

The gains per bushel of grain fed were as follows:

Kafir-corn whole and 14.58 pounds alfalfa hay..... 11.18 lbs.
Kafir-corn meal and 13.4 pounds alfalfa hay..... 10.85 "
Kafir-corn whole, alone..... 8.75 "
Kafir-corn meal alone..... 8.59 "
Kafir-corn meal four-fifths, soy-bean meal one-fifth..... 13.04 "

This experiment shows a slight loss from grinding the Kafir-corn, a great gain from feeding alfalfa hay with the Kafir-corn, and a greater gain from the use of soy-bean meal. The alfalfa hay, poor in quality, increased the gains 333 pounds per ton fed.

The following notes were made at the close of the experiment:

Lots 26 and 27.—Kafir-corn and alfalfa hay. Fattened evenly. Swift & Co.'s buyer reported them as showing good finish.

Lot 28.—Kafir-corn meal four-fifths, soy-bean meal one-fifth. Fattened uniformly; were very fat at the close of the trial. Swift & Co.'s buyer reported this to be the best fattened bunch having good finish.

Lot 29.—Kafir-corn whole. Four hogs well fattened and six poorly finished. Swift & Co.'s buyer reported this lot third grade, not showing good finish.

Lot 30.—Kafir-corn meal. Six hogs well fattened and four poorly finished. Swift & Co.'s buyer reported this lot fourth grade; poor quality both in fat and bacon finish.

The fifty head were shipped to the packers, Swift & Co., St. Joseph, Mo., who valued the different lots at the following prices per hundred pounds live weight: Kafir-corn and alfalfa hay lots, $3.67; Kafir-corn and soy-bean meal lots, $3.70; Kafir-corn alone lot, $3.65; and Kafir-corn meal alone lot, $3.60. Swift & Co. slaughtered each lot separately and made the following report:

Lot 26.—Ten hogs fed on alfalfa hay and whole Kafir-corn; live weight, 2060 pounds. This lot dressed 79½ per cent. from live weight, and when cut out, forty-eight hours after being killed, showed that they were good, firm-fleshed hogs, suitable for light-weight products. There was a good distribution of lean and fat in the bellies, though for firmness the meat was not equal to either lot 27 or lot 30.

Lot 27.—Ten hogs fed on alfalfa hay and Kafir-corn meal; live weight, 2060 pounds. This lot dressed 79 per cent. from live weight and the class of products from this lot is practically the same as from lot 26, distribution of lean and fat being good. The firmness of the fat in this lot was far above any of the others, and the fat had a good white color that is not customary in corn-fed hogs.

Lot 28.—Ten hogs fed on four-fifths Kafir-corn meal, one-fifth soy-bean meal; live weight, 2260 pounds. This lot dressed 80 per cent. from live weight, and the firmness of the fat in this lot is fair, but the cuts contained rather too great a proportion of fat for this weight hog, and for leanness would not compare with either lot 26 or lot 27.

Lot 29.—Ten hogs fed on whole Kafir-corn; live weight, 1800 pounds. This lot dressed 80.4 per cent. from live weight, and, while

the variations in weight were greater in this lot than in any of the others, it was the most suitable lot for bacon hogs of the five. There were a few hogs out of the ten that would have been suitable for English cuts, on account of the evenness of the fat and the good distribution of lean through the bellies.

Lot 30.—Ten hogs fed on Kafir-corn meal; live weight, 1790 pounds. This lot dressed 80 per cent. from live weight, and while the same average weight as lot 29, the hogs were fatter and not so adaptable for fancy bacon as lot 29. Firmness of the fat in this lot was good, but not as good as lot 27, but better than any of the others.

In our estimation, lots 26, 28, and 29, for firmness of the flesh, were no better than the regular corn-fed hogs, though it seems to us that corn-fed hogs of this weight would have been fatter. This excepts lot 28, which, as near as we could judge, were about as fat as corn-fed hogs of that weight would run.

Lots 27 and 30 had firmer flesh than would be found in a regular run of corn-fed hogs.

The yield of these lots from live weight was good, and on the last two lots was a little better than we would expect from the average hog.

PLATE II. Kafir-corn whole and alfalfa hay.

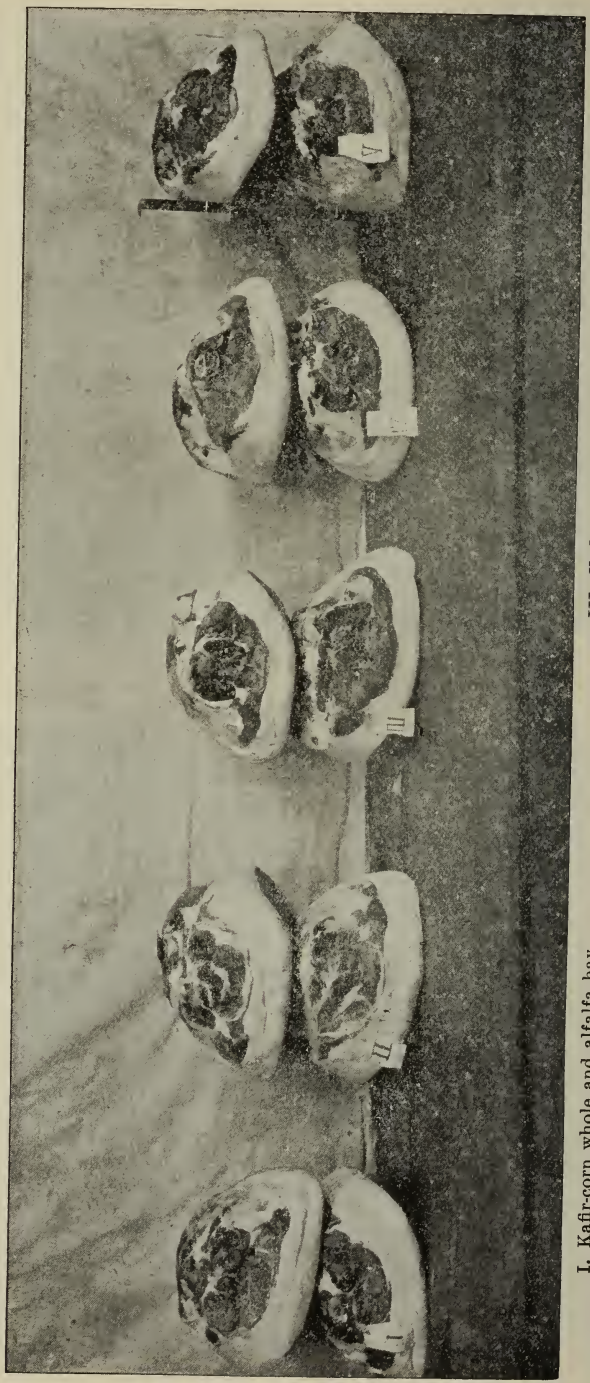
PLATE III. Kafir-corn meal and alfalfa hay.

PLATE IV. Kafir-corn four-fifths, soy-bean meal one-fifth.

PLATE V. Kafir-corn whole, alone.

PLATE VI. Kafir-corn meal alone.

PLATE VII.



I. Kafir-corn whole and alfalfa hay.
II. Kafir-corn meal and alfalfa hay.
III. Kafir-corn four-fifths, soy-bean meal one-fifth.
IV. Kafir-corn whole, alone.
V. Kafir-corn meal alone.

SEVENTH EXPERIMENT.

Eighty hogs were used in this experiment, and the plan was to show the value of our drought-resisting feeds for summer fattening. The hogs were mixed-bred hogs purchased of farmers, and were of average quality.

The alfalfa pasture was four years old and a poor stand. Each lot of hogs having pasture had the run of 1.87 acres of alfalfa. The first crop was mowed for hay before the hogs were turned on. At the end of the fourth week of the experiment the pastures were cut for hay a second time, as the hogs did not keep the growth eaten down. The pastures proved to be too large for the number of fattening hogs put on them, allowing the hogs to run too much.

The skim-milk used was sterilized skim-milk purchased of the Manhattan creamery. One day each week skim-milk could not be obtained and buttermilk was used in its place, experiments at other stations showing that skim-milk and buttermilk have the same feeding value.

The grain of the hogs fed milk was put in the feed-trough dry and the milk poured over it. The grain for the other lots was wet with water at the time of feeding.

This experiment began March 30 and continued forty-two days.

Lot No....	VII. Feed.	Hogs in lot.....	Average weight per head, lbs.		Gain, lbs.		Grain fed, pounds.			Lbs. feed for 100 lbs. gain.	
			Beginning....	Close.....	Av. daily gain per head...	Av. total gain per head...	Total pounds.	Per day per head.....	Pounds gain per bushel of grain....	Grain.....	Skim-milk....
31	Kafir-corn whole, skim-milk, and alfalfa pasture.....	20	124.40	194.95	1.68	70.55	6,736	8.02	11.73	**477**	***298**
32	Kafir-corn whole and skim-milk.....	20	124.35	190.30	1.57	65.95	6,601	7.86	11.19	**500**	**318**
33	Kafir-corn whole.	20	124.20	165.90	.99	41.70	5,321	6.33	8.78	**638**	.....
34	Kafir-corn whole and alfalfa pasture.....	20	124.55	169.00	1.08	45.23	4,931	5.97	10.11	**554***	.....

*Pasture to be added.

The gains per head for the forty-two days from the different methods of feeding were as follows:

Whole Kafir-corn..... 41.7 lbs.
Whole Kafir-corn and alfalfa pasture..... 45.2 "
Whole Kafir-corn and skim-milk..... 66.0 "
Whole Kafir-corn, alfalfa pasture, and skim-milk..... 70.6 "

This shows poor returns from the alfalfa pasture. The hogs were fed all the grain they would eat, and fed but little on the pasture, while the pasture allowed them too much exercise. To get the most out of

pasture, hogs should be given a light grain ration. Prof. E. M. Shelton, at this College, showed a gain of 776 pounds of pork per acre of alfalfa pasture, with hogs fed little grain. The hogs having both pasture and skim-milk with the Kafir-corn made the best gains.

It required 638 pounds of whole Kafir-corn to make 100 pounds of gain, and 500 pounds whole Kafir-corn and 318 pounds of skim-milk to make 100 pounds of gain—318 pounds of milk in this trial producing as much gain as 138 pounds of Kafir-corn. This shows 129 pounds of creamery skim-milk fed with Kafir-corn to have the same feeding value as one bushel of whole Kafir-corn fed alone. With hogs at three cents per pound live weight, the skim-milk fed with Kafir-corn brought twenty cents per hundred pounds. The hogs were fed five pounds of milk each per day.

By the end of the seventh week the hogs seemed to have passed the most profitable feeding period. The weather was hot and the hogs began to eat less. The hogs having pasture, those fed skim-milk and those having skim-milk and the pasture were in good condition. The hogs fed the Kafir-corn alone were not finished.

The hogs were shipped to Armour & Co., Kansas City, for slaughter test, who made the following report:

Lot 31.—Twenty hogs fed on Kafir-corn, skim-milk, and alfalfa pasture; live weight, 3770 pounds; yielded 80.53 per cent. When cut out, the flesh showed a good, firm condition; nice white fat and better proportion of fat to weight of hogs than in any of the other lots. The distribution of lean and fat in bellies not so good as in lots 32 and 34.

Lot 32.— Twenty hogs fed on Kafir-corn and skim-milk; live weight, 3700 pounds; yielded 81.17 per cent. When cut out, showed condition of flesh same as in lot 31. One hog in this lot showed fat very yellow, others good white color. Proportion of fat to weight of hogs not so good as either lot 31 or 34; distribution of lean and fat in bellies better than in lots 31 and 33.

Lot 33.—Twenty hogs fed on Kafir-corn alone; live weight, 3260 pounds; yielded 80.30 per cent. When cut out, showed flesh very irregular and rather soft. Color of fat about the same as in other lots but softer. Neither the proportion of fat to weight of hogs or distribution of lean and fat in bellies as good as any of the other lots.

Lot 34.—Twenty hogs fed Kafir-corn and alfalfa pasture; live weight, 3340 pounds; yielded 81.05 per cent. When cut out, showed condition of flesh firm, not quite up to lots 31 and 32; color of fat good; proportion of fat to weight of hogs not so good as lot 31, bet-

ter than lots 32 and 33; distribution of lean and fat in bellies better than lots 31 and 33, about the same as lot 32.

EIGHTH EXPERIMENT.

Feeding Cholera Hogs.—Sixty-six hogs were used in this experiment. In June, 1899, 115 weaned pigs were purchased; and 320 pigs, averaging sixty pounds each, were purchased in August, 1899, with the object of continuing our work with drought-resisting feeds for fattening hogs. Each lot was inoculated at time of purchase with virus for the prevention of hog-cholera. The pigs were attacked with the cholera, and all but sixty-six head died. These appeared well, but were in thin flesh, as a result of the disease. Our plans for experiments had to be dropped, and it was desirable to fatten the hogs that were alive as soon as possible. Thirty head were divided into three lots of ten each. The remaining thirty-six head were used as a check on lot 37. The feeds selected were those that we judged from previous experiments would produce the most rapid gains.

The table shows the methods of feeding, the amount of feed, and the gains.

The experiment began October 3, 1899, and continued ninety-seven days.

Lot No....	VIII. Feed.	Hogs in lots.....	Average weight per head, lbs.		Gain, lbs.		Total pounds feed.			Pounds feed for 100 pounds gain.		
			Beginning....	Close.....	Average daily gain per head.....	Average total gain per head.....	Kafir-corn..	Alfalfa hay.	Skim-milk..	Kafir-corn..	Alfalfa hay.	Skim-milk..
35	Kafir-corn whole, soy bean meal, and alfalfa hay.....	10	109.7	188.5	.81	78.8	4,960	1,148	.....	**629**	**145+**	.....
36	Kafir-corn whole, soy beans whole, and alfalfa hay.....	10	109.7	205.0	.98	95.3	5,393	1,148	.....	**566**	**120.4**	.....
37	Kafir-corn whole, soy beans whole, alfalfa hay, and skim-milk ...	10	82.0	196.5	1.18	114.5	4,622	1,148	4,239	**403.6**	**100+**	**370.2**
38	Kafir-corn whole, soy beans whole, alfalfa hay, and skim-milk ...	36	90.6	211.1	1.31	120.5	20,380	2,192	7,447	**469**	**50.5**	**171.6**

The gains are poor considering the character of the feed given. The hogs in all lots would eat a light feed with relish, but would not stand heavy feeding. The cholera seemed to have lessened their ability to consume feed.

The hogs fed skim-milk made the most rapid gains, and required the least amount of grain for 100 pounds of gain. Lot 38, which had milk, was finished in ninety-two days and sold. The other lots required ninety-seven days in which to fatten.

The only point of value brought out by this experiment is the loss from grinding soy beans. The hogs having ground soy beans requiring over eleven per cent. more meal to make 100 pounds of gain than those fed the beans whole.

VALUE OF BREED AND TYPE.

The hogs fed in the first three experiments were pure-bred hogs raised by the College, and were good types of Berkshires and Poland-Chinas. In the remaining five experiments the hogs were purchased of farmers and were of mixed breeding, mostly Berkshire and Poland-China crossed, of average quality. In the third experiment pigs were fed, and in the first and second trials hogs. Taking the average gains of the pure-bred hogs in the first and second experiments, and the average gains of the mixed-bred hogs fed by the same methods, the amount of feed required to make 100 pounds of gain is, dropping fractions, as follows:

	Pure-bred hogs.	Mixed-bred hogs.	Increase in feed needed by mixed-bred hogs.
Kafir-corn whole, dry	527	647	23 per cent.
Kafir-corn meal wet	515	672	30 " "
Kafir-corn meal four-fifths, soy-bean meal one-fifth	409	452	10 " "

This showing that average mixed-bred hogs required from ten to thirty per cent. more feed for 100 pounds gain than good pure-bred hogs is a strong argument for better breeding. The scrub hog should go.

In these experiments we found many well-built hogs among those we purchased—hogs that would stand heavy feeding and make good returns for the feed. We found two mistakes common in the mixed-bred hogs. One class had good hind quarters, but were low in front and weak through the heart. Such hogs get off feed easily, often will not stand heavy feeding, and take disease readily. The other unprofitable class is the "chunk," the fine-boned, short, blocky hog with heavy jowls. This is the form of hog the feeder often breeds for, after he has found the weakness of the first class described. The "chunk" is fat or can be quickly fattened, but will not eat enough feed to make profitable gains.

The hogs that made the best gains in these experiments were well boned, with both fore and hind quarters well developed, rather rangy, well developed through the heart, with heavy-boned legs of fair length.

PLATE VIII. The "chunk."

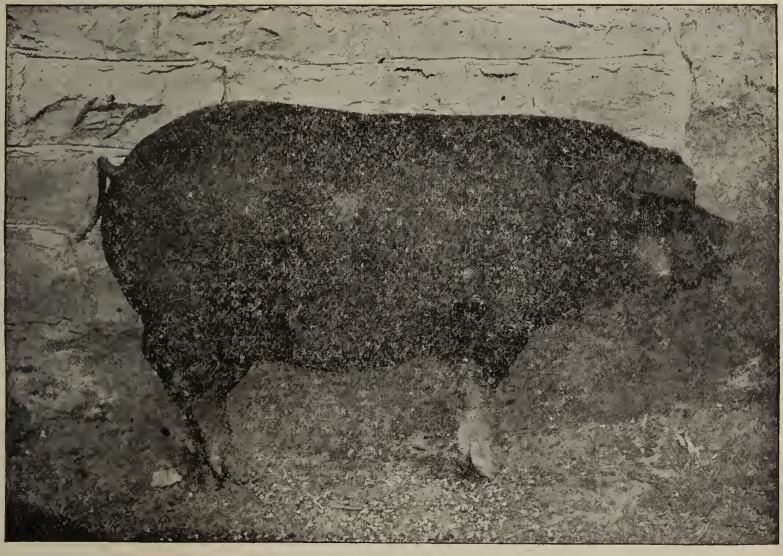


PLATE IX. The hog that makes profitable gains.

FEED REQUIRED FOR ONE HUNDRED POUNDS OF GAIN.

Twenty-five different lots of hogs have been fattened on grain alone. The different lots show wide variations in the amount of feed required to make 100 pounds gain.

Lot No.	Feed.	Feed required for 100 lbs. gain.
16	Corn-meal two-thirds, soy-bean meal one-third	369 lbs.
14	Kafir-corn meal two-thirds, soy-bean meal one-third	374 "
12	Kafir-corn meal four-fifths, soy-bean meal one-fifth	408 "
6	Kafir-corn meal four-fifths, soy-bean meal one-fifth	409 "
28	Kafir-corn meal four-fifths, soy-bean meal one-fifth	435 "
5	Kafir-corn meal one-half, corn-meal one-half	456 "
4	Shelled corn, dry	457 "
19	Kafir-corn meal four-fifths, soy-bean meal one-fifth	468 "
3	Kafir-corn meal, wet	471 "
11	Kaffir-corn meal one-half, corn-meal one-half, wet	477 "
10	Shelled corn, dry	479 "
15	Corn-meal, soaked forty-eight hours	484 "
7	Kafir-corn whole, dry	512 "
24	Kafir-corn meal and cottonseed-meal	540 "
1	Kafir-corn whole, dry	542 "
13	Kafir-corn meal, soaked forty-eight hours	542 "
8	Kaffr-corn whole, soaked forty-eight hours	550 "
9	Kafir-corn meal, wet	559 "
2	Kafir-corn whole, soaked forty-eight hours	632 "
33	Kafir-corn whole, wet	638 "
29	Kafir-corn whole, wet	640 "
30	Kafir-corn meal, wet	653 "
20	Kafir-corn whole, dry	655 "
22	Kafir-corn meal, wet	691 "
21	Kafir-corn meal, dry	749 "
	Average	528 lbs.

This table shows the average amount of feed required to produce 100 pounds of gain was 528 pounds of grain, with variations in feed ranging from 369 pounds to 749 pounds of grain. It is noticeable that the hogs requiring the least amount of feed for 100 pounds gain had soy-bean meal in their rations. The six lots of hogs having soy beans as part of their ration required an average of 411 pounds of grain for 100 pounds of gain, while the nineteen lots not fed soy beans required an average of 564 pounds of feed for 100 pounds of gain, an increase in food required of over thirty-seven per cent. The moral of this is, raise and feed soy beans. Skim-milk and alfalfa hay also greatly reduced the amount of grain required for 100 pounds gain.

PREPARATION OF FEED.

Grinding Kafir-corn gave greatest returns in our first experiment, showing a saving of thirteen per cent. in amount of feed required for 100 pounds of gain. In all other trials Kafir-corn meal gave less gains than the whole grain, the loss from grinding being nine and fourteen per cent. in the different trials.

Soaking the Kafir-corn resulted in losses of seven and seventeen per cent.

Wetting the grain at the time of feeding gave best results, and this is the method we recommend. We put the whole grain dry into the trough and pour over it sufficient water or skim-milk to thoroughly wet the grain. When water is used we add enough to have a little left in the trough after the grain in eaten. Kafir-corn is dusty, and when fed dry makes hogs cough.

Grinding alfalfa hay resulted in a loss, and we recommend the hay to be fed whole, just as to cattle.

Grinding the soy beans caused a loss of eleven per cent. in the one experiment where both ground and whole beans were fed.

KAFIR-CORN.

In the first and second trials an average gain is shown of 100 pounds from 527 pounds of Kafir-corn or from 468 pounds of corn, a bushel of Kafir-corn producing 10.6 pounds gain, a bushel of corn 11.9 pounds. In these trials a bushel of Kafir-corn had eighty-nine per cent. of the feeding value of corn. For the past eleven years the average yearly yield per acre on the College farm — upland — has been: Kafir-corn, 46 bushels; corn, 34½ bushels. This shows an average yearly yield of grain to produce, per acre, from Kafir-corn 487 pounds of pork, from corn 410 pounds of pork. A bushel of corn will produce more pork than a bushel of Kafir-corn. On the College farm, an acre of Kafir-corn will produce more pork than an acre of corn. Kafir-corn is our most vigorous plant on upland soils, and is a strong drought resister.

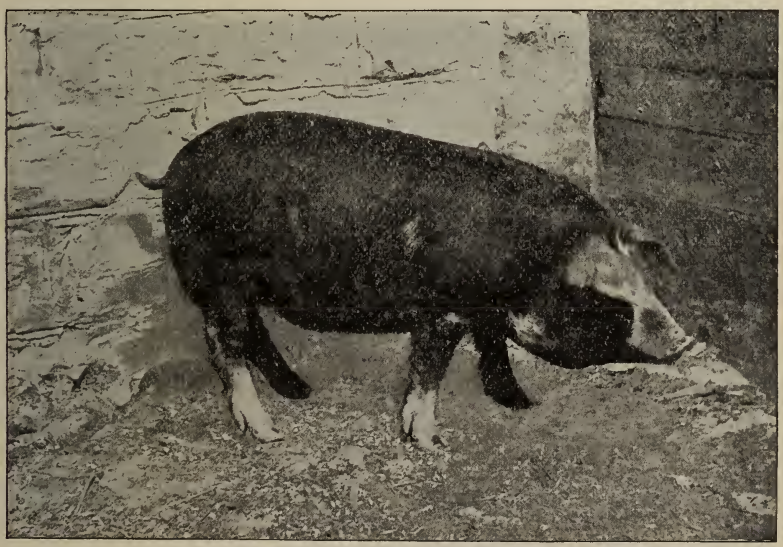


PLATE X. The Kafir-corn-fed hog.

Hogs tire of Kafir-corn alone much more quickly than they do of corn alone. Hogs like this grain at first, and when fed Kafir-corn alone eat it with relish for about four weeks, gaining as fast as if fed corn. Then they become tired of it and show intense longing for other feed. If no other feed is given they will eat their bedding in an effort to get variety, and show every sign of loathing the Kafir-corn. Their tails hang down, their heads droop, and the general appearance is dispirited. The cut gives a fair idea of the Kafir-corn pig at the end of six weeks' feeding.

Kafir-corn is our most constipating grain, and it is to this quality that we attribute its effect on the hog's appetite, as on this account hogs fed exclusively on Kafir-corn become feverish and unthrifty. When laxative feeds are given with Kafir-corn the hog's appetite is vigorous through a long feeding period.

Often a mature hog will continue to make good gains from Kafir-corn alone until well fattened. After young hogs become tired of an exclusive diet of Kafir-corn it is difficult to get them to eat enough of this grain to thoroughly fatten. A bunch of hogs fed Kafir-corn alone fattens unevenly, some becoming well fattened, some moderately fat, and others remaining thin, although increasing in weight. This has been true of every lot we have fed on Kafir-corn alone, no matter how even the hogs seemed to be at the beginning of the trial.

Kafir-corn fed with alfalfa, soy beans or skim-milk is eaten with relish every meal until the hogs are thoroughly finished and the lot fattens evenly.

ALFALFA HAY.

In the fourth experiment alfalfa hay was fed to two lots being fattened on Kafir-corn. The hogs fed hay ate more grain and gained more for each bushel eaten, showing a gain of 868 pounds of pork per ton of alfalfa hay fed whole, and 716 pounds of pork per ton of alfalfa hay fed ground. The hogs having both grain and hay gained an average of 90.9 pounds each, while the hogs fed grain alone gained an average of 52.4 pounds each, showing 73 per cent. increase in gain from feeding the hay. The gains per bushel of feed were as follows:

Kafir-corn meal and 7.83 pounds alfalfa hay	10.88 lbs.
Kafir-corn meal alone	7.48 "

Valuing the hay at three dollars per ton and fat hogs at three cents per pound live weight, the Kafir-corn fed alone brought 22.4 cents per bushel, and the Kafir-corn fed with alfalfa hay brought 31.4 cents per bushel.

The hay fed in the fourth trial was early cut and carefully cured with the leaves on. In our sixth trial alfalfa hay was used that was

cut late, and many of the leaves were lost in curing. The experiment showed a gain of 333 pounds per ton of the hay fed. The hogs having both grain and hay gained 68.5 pounds each, and the hogs having Kafir-corn alone gained 45.6 pounds each, showing 50 per cent. increase in gain from feeding from poor alfalfa hay. The gains per bushel of feed were as follows:

Kafir-corn whole and 14.58 pounds alfalfa hay..... 11.17 lbs.
Kafir-corn whole, alone..... 8.75 "

Valuing the hay at three dollars per ton, and fat hogs at three cents per pound live weight, the Kafir-corn fed alone brought 26.2 cents per bushel, and the Kafir-corn fed with alfalfa hay brought 33.2 cents per bushel.

These trials with alfalfa hay show two things: the great value of alfalfa hay to feed with Kafir-corn, and the need of cutting it early and carefully curing it. The hogs eat the leaves. Alfalfa hay for hogs should be cut before more than half the plants are in bloom and handled in curing to save every leaf possible.

SOY BEANS.

The soy bean stands drought as well as Kafir-corn or sorghum, is not touched by chinch-bugs, and does well on poor soils. Every experiment in which soy beans were tried shows that, when part of the ration was beans, the hogs having them ate the most grain, and made the most gain for feed eaten. The results are:

Experiments.	Average gain per hog, lbs.	Increased gain from soy beans, per cent.	Pounds feed for 100 lbs. gain	Per cent. feed saved by feeding soy beans
First Experiment:				
Kafir-corn meal	90.6	.....	471	.....
Kafir-corn meal four-fifths, soy-bean meal one-fifth	103.8	14.6	409	13.2
Second Experiment:				
Kafir-corn meal	102.0	.....	559	.....
Kafir-corn meal four-fifths, soy-bean meal one-fifth	145.7	42.8	408	27.0
Third Experiment:				
Kafir-corn meal	74.2	.....	542	.....
Kafir-corn meal two-thirds, soy-bean meal one-third	129.2	74.1	374	31.0
Corn-meal	82.6	.....	484	.....
Corn-meal two-thirds, soy-bean meal one-third	120.4	45.5	369	23.7
Fourth Experiment:				
Kafir-corn meal	52.4	.....	749	.....
Kafir-corn meal four-fifths, soy-bean meal one-fifth	97.8	86.5	468	37.5
Sixth Experiment:				
Kafir-corn meal	44.1	.....	653	.....
Kafir-corn meal four-fifths, soy-bean meal one-fifth	86.6	96.4	435	33.2

This table shows an increase in gain of from 14.6 to 96.4 per cent. by making the ration one-fifth soy beans, and that the rations containing one-fifth soy beans show a saving in the amount of feed required to make 100 pounds of gain from 13.2 to 37.5 per cent. Can the Kansas farmer afford to fatten hogs without soy beans? Hogs fed soy beans fatten rapidly, look thrifty, have strong appetites, and the hair and skin are glossy, like those of animals fed oil-meal. The soy bean is a rich feed and we do not recommend more than one-fifth to one-third of the ration to be made of the beans. Soy beans may be fed whole, mixed with the other grain, or unthrashed beans, stalk and all, may be thrown to the hogs and they will quickly pick out the beans. We lost eleven per cent. from grinding the beans.

SKIM-MILK.

In our fifth experiment creamery skim-milk was fed, and shows the following results:

Feed.	Gain per hog, lbs.	Pounds feed for 100 pounds gain.		
		Kafir-corn.	Hay.	Skim-milk.
Kafir-corn meal and alfalfa hay	19.5	538	214	.....
Kafir-corn meal and skim-milk	52.5	268	.....	526

The hogs having the skim-milk made over 169 per cent. more gain than the hogs not fed milk, and 526 pounds of skim-milk instead of 214 pounds of alfalfa hay reduced by 50 per cent. the amount of feed required to make 100 pounds of gain. Valuing the Kafir-corn at 55 cents per hundred and hogs at three cents per pound live weight, we realized 29 cents per hundred from feeding the skim-milk.

In our seventh experiment whole Kafir-corn was fed to one lot of hogs and whole Kafir-corn and creamery skim-milk to another lot.

Feed.	Gain per hog, lbs.	Pounds feed for 100 lbs. gain.	
		Kafir-corn.	Skim-milk.
Kafir-corn	41.7	638	.....
Kafir-corn and skim-milk	65.9	500	318

The hogs having the skim-milk made 58 per cent. more gain than those not fed milk, and 230 pounds of milk took the place of 100 pounds of grain. Valuing whole Kafir-corn at 50 cents per hundred and live hogs at three cents per pound, the skim-milk brought 15.7 cents per 100 pounds.

COTTONSEED-MEAL.

We fed cottonseed-meal to one lot of hogs that had not done well in another experiment, and they were ready for market, well finished, in twenty two days. Cottonseed-meal fed in large quantities or for long periods is death to hogs. Fed for a short time, in small quantities, it is valuable to put hogs in good condition that are not doing well. We begin by feeding one-fourth pound of cottonseed a day per 1000 pounds live weight of hogs, and increase each day to ten days, when we feed per day three pounds per 1000 pounds live weight of hogs, mixing the meal with the other grain. This quantity of cottonseed can be profitably fed three to four weeks.

VALUE OF PROTEIN AND MINERAL MATTER.

These experiments bring out strongly the value of these materials in making increased gains from food consumed. In each trial where a feed rich in protein and mineral matter was added to Kafir-corn or corn the addition made variety and the ration was more appetizing. This helped to increase the gain, as is shown in the trials where corn was added to Kafir-corn. After allowing full value to the increased gain from the effect of variety, we still have a greater part of the increase to be accounted for by the influence of the protein and mineral matter in the feeds given with Kafir-corn.

The table gives the composition of the feeds given in the eight experiments.

Feeds.	Mineral matter, per cent.	Digestible nutrients, pounds per 100 lbs. feed.			Nutritive ratio. 1 to—
		Protein.	Carbohydrates.	Fat.	
Corn	1.5	7.8	66.7	4.3	9.7
Kafir-corn	2.5	7.3	65.2	.....	8.9
Soy beans	4.7	29.6	22.3	14.4	1.8
Cottonseed-meal	7.2	37.2	16.9	12.2	1.2
Skim-milk	0.7	3.9	4.5	0.1	1.2
Alfalfa hay	10.5	14.5	43.0	1.0	3.1

Note.—The analyses of the alfalfa hay and Kafir-corn were made by the chemical department of this Station during the progress of these experiments, and represent the composition of the feed given the hogs. The analyses of the other feeds represent the average composition, as given by our best authorities.

Taking the results obtained from lots where grain only was fed, we have the following showing in regard to the value of protein and mineral matter:

	Protein, pounds.	Mineral matter, pounds.	Pounds feed for 100 lbs. gain.
Corn 66⅔ pounds, soy beans 33⅓ pounds	15.1	2.6	369
Kafir-corn 66⅔ pounds, soy beans 33⅓ pounds	14.8	3.3	374
Kafir-corn 80 pounds, soy beans 20 pounds	11.8	2.9	408 to 468
Corn 100 pounds	7.8	1.5	457 to 479
Kafir-corn 100 pounds	7.3	2.5	471 to 749

This is a strong showing of the value of feeds rich in protein and mineral matter for fattening hogs, as it shows that as the protein and mineral matter were increased the amount of feed required for 100 pounds of gain decreased.

The mineral matter is needed in the growth of bone and flesh, and neither corn nor Kafir-corn furnishes a sufficient quantity to supply the needs of the hog. The need of mineral matter is much greater in hogs that are growing while being fattened than in mature animals. In other experiments we have kept pigs in a stone piggery, and those fattened on corn or Kafir-corn alone craved mineral matter so intensely that they ate the mortar from between the stones.

Protein is needed to form blood and flesh and is used to form fat in the body. Neither corn nor Kafir-corn supplies it in sufficient quantities, as is seen in the much better results obtained where additional protein was furnished by the soy beans. Soy beans contain the most protein of any crop that can be raised on Kansas farms, and alfalfa comes next.

The profits made by adding more protein to a ration of Kafir-corn are easily shown from the results obtained in our sixth experiment. In this experiment one bushel of Kafir-corn and 7.83 pounds alfalfa hay gave 10.88 pounds gain, and one bushel of Kafir-corn alone gave 7.48 pounds gain. Fifty acres of Kafir-corn yielding forty-six bushels per acre, our average on upland, will produce 2300 bushels, which would produce, with the quality of hogs used in this experiment, 17,204 pounds gain, worth $516.12 with hogs at three cents per pound live weight. Hogs fed this amount of Kafir-corn would eat nine tons of the best quality of alfalfa hay. This Kafir-corn and alfalfa together would produce 25,024 pounds gain, worth, at three cents, $750.72, a profit of $234.60 by adding the protein in nine tons of hay to the Kafir-corn raised on fifty acres.

WHAT THESE EXPERIMENTS SHOW FOR KANSAS.

We have had but one failure of Kafir-corn in eleven years. It gives a good grain yield on upland, and is our surest crop in drought. Soy beans give a fair yield on upland, stand drought well, and are not touched by chinch-bugs. Alfalfa can usually be raised in the draws of the highest upland Kansas farms; yields at least one crop in the dryest year, and usually two to four crops a year on most farms.

These experiments show that Kafir-corn and either soy beans or alfalfa, properly combined, produce good results in fattening hogs. On an upland farm an acre of Kafir-corn will produce more pork than an acre of corn. Kafir-corn fed alone to hogs does not give nearly so large gains as when fed with soy beans or alfalfa hay. Kafir-corn combined with either soy beans or alfalfa hay will produce more

pounds of pork per acre from upland than are usually produced from adjoining bottom lands from corn. Kafir-corn, or its near relatives, rice-corn and Jerusalem corn, yield well in every part of the state. The experiments reported in this bulletin show that, by combining soy beans or alfalfa hay with Kafir-corn, hogs may be fattened profitably on every farm in the state. Corn should be raised where it will yield more than Kafir-corn, and Kafir-corn where its yield is the higher.

Skim-milk fed with Kafir-corn made our best gains, and the 30,000 patrons of Kansas creameries can increase their profits by feeding their skim-milk with Kafir-corn, using the methods of feeding which this bulletin shows to be the best.

Pure-bred hogs gave so much better gains per bushel of feed than average hogs that the value of breeding up cannot be questioned.

The yields we have obtained from Kafir-corn, soy beans, and alfalfa hay, the showing of only one crop failure in eleven years, and the good results obtained from fattening hogs with combinations of these feeds, show a greater certainty of crop and more pounds of pork per acre than are usually secured by ordinary feeds in other states.

EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN No. 96—MAY 1900.

FARM DEPARTMENT.

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D. H. OTIS, M. S., Assistant in Dairying.
J. G. HANEY, B. S., Assistant in Field and Feeding Experiments.

SOIL INOCULATION FOR SOY BEANS.

THE study of soil inoculation for soy beans was first made at this Station by D. H. Otis as a part of his work for the degree of master of science. His investigations indicated that if practicable methods of soil inoculation for large fields could be developed they would prove of great value in providing a cheap method of enriching long cultivated soils. Mr. Otis completed his work in 1897 and in 1898 the Farm Department began the work of inoculation on a field scale.

In this bulletin the work of Mr. Otis is given first, while the work of the department in inoculating large fields begins on page 112.

Root Tubercles and their Production by Inoculation.

BY D. H. OTIS, M. S.

GENERAL STATEMENT.—By examining the roots of such plants as clover, alfalfa, beans, and peas, one will usually find, scattered over their exterior surface, tubercles of various sizes and shapes. These tubercles, are, with very few exceptions, peculiar to a certain order of plants known as Leguminosæ. These tubercles are the outgrowths of the plants themselves, and are produced by the action of certain micro-organisms working within the tissues of the root. Formerly these tubercles were considered abnormal appendages and as injurious to

the plants, but later observations revealed the fact that where these tubercles were wanting, the plants did not make the growth that was made by plants where the tubercles were present. Later examination has brought out the fact that these tubercles are the homes of minute microscopic bacteria (*Bacillus radicicola* Beyer). The bacteria have the remarkable property of taking the free nitrogen of the atmosphere and transforming it into available compounds for plant-food. So it is a case of symbiosis, the plant furnishing food and shelter for the bacteria, and the bacteria, in turn, furnishing the plant with nitrogen. This is what makes the leguminous plants so valuable as soil enrichers, and especially prized for green manuring.

All the problems connected with the assimilation of free nitrogen through the intervention of root tubercles have by no means been solved. Even the best authorities seem to disagree on some points. However, it is pretty well settled that the tubercles are the result of a micro-organism, but it has been proven that the organism producing tubercles on the pea or bean will not produce tubercles on clover and alfalfa, and *vice versa*. Whether these organisms are different species for different plants, or a modification of the same species, is yet a disputed question. Again, as the organisms attack the root, it is supposed that they exist in the soil, and the question would naturally arise as to whether they could be transported and spread with the soil, and, if so, whether that is the only way; or whether the seed from plants with tubercles will produce tubercles when grown in soil devoid of the organism adapted to that particular plant. To test some of these questions, and others connected with them, experiments were carried on with the soy bean (*Glycine hispida* Maxim).

EXPERIMENTS IN THE FIELD.

Methods of Inoculation.—Since 1890 soy beans have been grown at the Kansas Experiment Station, but frequent and numerous examinations of the roots fail to reveal the presence of any nodules or tubercles. Knowing that the Hatch Experiment Station, Amherst, Mass., had been successful in producing tubercles on the soy bean, it was proposed that an attempt be made to inoculate the Kansas beans with Massachusetts soil. The soil arrived in a dry, pulverized condition, not unlike the dust in our roads during a dry season. The field experiment was situated on a sandy loam soil with a western exposure, and consisted of two series of three plats each. Series I was planted with Yellow Soy beans, in which the plats were treated as follows: Plat A was inoculated with soil, plat B with extract, and plat C was not treated. Series II was a repetition of series I, with the exception that the Medium Green bean, a variety grown at the Hatch Experiment Station, was used instead of the Yellow Soy. The object was

SERIES I: **A**, inoculated with soil; **B**, inoculated with extract—(1) at time of planting, (2) once after planting, (3) three times after planting; **C**, not treated.

				1	2	3					
o	o	o		o	o	o		o	o	o	
o	o	o		o	o	o		o	o	o	
o	o	o		o	o	o		o	o	o	
o	o	o	Guard row	o	o	o	Guard row	o	o	o	
	—A—				—B—				—C—		
o	o	o		o	o	o		o	o	o	
o	o	o		o	o	o		o	o	o	
o	o	o		o	o	o		o	o	o	
o	o	o		o	o	o		o	o	o	

SERIES II: **D**, inoculated with soil; **E**, inoculated with extract—(4) at time of planting, (5) once after planting, (6) three times after planting; **F**, not treated.

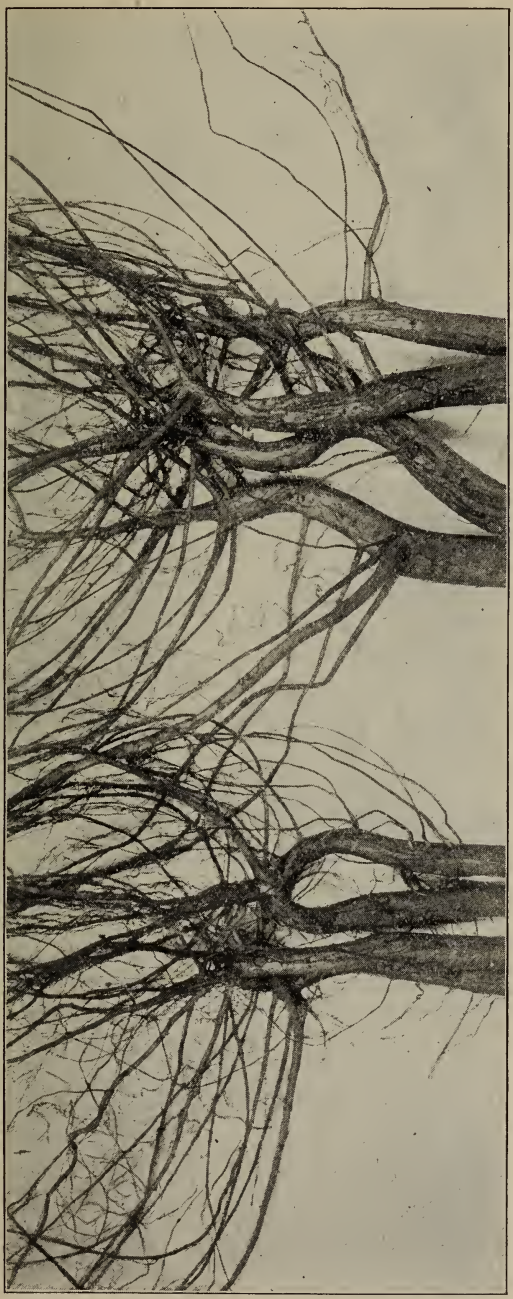
				4	5	6					
o	o	o		o	o	o		o	o	o	
o	o	o		o	o	o		o	o	o	
o	o	o		o	o	o		o	o	o	
o	o	o	Guard row	o	o	o	Guard row	o	o	o	
	—D—				—E—				—F—		
o	o	o		o	o	o		o	o	o	
o	o	o		o	o	o		o	o	o	
o	o	o		o	o	o		o	o	o	
o	o	o		o	o	o		o	o	o	

to note whether there was any difference in the production of tubercles between a variety whose seed was obtained from plants grown in Massachusetts soil and seed obtained from plants grown in Kansas soil. Both series were seeded May 29, 1896. Each plat contained three rows two and one-half feet apart, and each row contained eight hills twenty inches apart. Between the plats was placed a guard row in which the beans were not treated and were planted in drills from two to three inches apart. The arrangement of the series and the plats is shown in the accompanying plan.

On plats A and D about one-twentieth of a pint of the pulverized Massachusetts soil was placed in the bottom of each hill and the beans placed on top of this. Plats B and E were treated with an extract of the Massachusetts soil. This extract was obtained by mixing a quantity of soil with about seven times its bulk of water, stirring thoroughly, and allowing the soil to settle, after which the water was poured off and used for the inoculation. The aim was to use about the same quantity of soil in obtaining the extract as was used on the same number of plants where the soil was applied direct. Rows 1 and 4 of plats B and E, respectively, were inoculated at the time of planting, *i. e.*, about one-sixth of a pint of the extract was poured in the bottom of each hill just previous to planting the beans Rows 2 and 5, 3 and 6, were inoculated June 13, seven days after the plants were up, and rows 3 and 6 were again inoculated on July 2 and July 17, or twenty-six and forty-one days, respectively, after the plants appeared above ground. The extract reached the roots through a round hole made with a pointed stick. Plats C and F were planted in the same manner as the others except the inoculation. The purpose of these plats was to serve as a check on the others, and, at the same time, as a means of comparison with the inoculated plats as regards growth and general appearance.

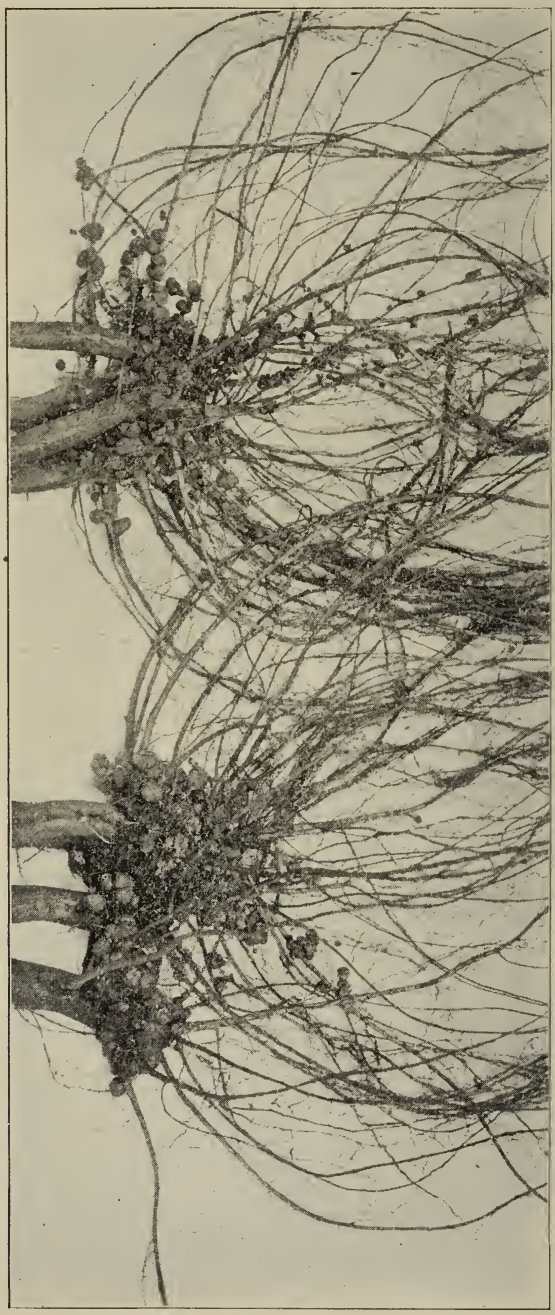
Culture and Growth.—The season was favorable to the growth of the beans. The beans were up June 6. On June 13 some of the extra plants were pulled up, and there were found several well-defined nodules on the roots of those inoculated with soil, but none were found on any of the others at this date. June 22 it was noted that the beans inoculated with soil appeared to have a little larger growth. The difference was not very striking, however. On July 14 the Yellow Soys were in full bloom, but the Medium Green, being a little later variety, did not appear in full bloom until July 20. Measurements were taken for the average heights of the plants on August 20, with the result that the Yellow Soy showed greater height than the Medium Green. This was due, however, to the difference in the variety, the latter being a late-maturing and a somewhat more bushy

PLATE I.



Not inoculated.

PLATE II.



Inoculated with Massachusetts soil.

PLATE III.

Inoculated with extract.

plant than the Yellow Soy. It was also noticed that in plats B and E, rows 1 and 4, inoculated at time of planting, attained, on the whole, a little greater height than rows 2 and 5, and 3 and 6, inoculated subsequently to the time of planting. This would indicate that the best time to inoculate is at the time of planting. Furthermore, the plants inoculated with soil averaged a little greater height than the others. However, the differences above noted are not great, and, with the exception of the difference due to variety, would not be noticed by the ordinary observer without the application of a measuring rod.

Appearance of the Roots.—On August 27 two hills each of the treated plats and one of the untreated were dug up, together with about a two-foot cube of the soil surrounding each hill. These were placed in large tubs of water, and, after a thorough soaking, the roots were carefully washed out and examined for tubercles. The latter were found in great number and of large size on the inoculated plants, but not a single tubercle could be found on the plants not treated, from either the Yellow Soy or the Medium Green; nor were there any signs of tubercles on the plants in the guard rows between the inoculated plants. The tubercles on the plants inoculated with soil were fairly uniform and situated mainly on the upper portion of the roots, not far from where the soil was placed at the time of planting. In case of the plants inoculated with extract, there was a marked difference between the varieties; the tubercles on the Yellow Soy were very numerous and well developed, while those on the Medium Green were scanty and rather inferior. All the inoculated plants showed a greater diameter of the lower portion of the stem than the plants not treated. Pictures were taken of the different treatments, and are here given. (See plates I, II, and III.)

Nitrogen Content.—On September 17 an average sample of six stalks each was taken from plats D and F of series II for analysis, with the purpose in view of ascertaining whether there would be any difference in the content of nitrogen between the plants with tubercles and those without tubercles. The seed being the most constant in composition of any part of the plant, it was thought that the difference, if any, would be in the fodder; and so, after the samples were thoroughly dried, the beans were all shelled out and the fodder ground up fine. From this a sample was taken and pulverized for analysis. The per cent. of nitrogen is shown in the following table, together with the protein and water.

Table I.

Treatment.	Nitrogen.	Protein.	Water.
Inoculated with soil	1.439%	8.996%	7.89%
Not treated	1.395	8.719	7.30
Difference	0.044%	0.277%	0.59%

The analysis does not show any great difference in favor of inoculating, there being an increase of only .04 of 1 per cent. of nitrogen and .27 of 1 per cent. of protein in favor of the beans with tubercles. This would be .8 pound nitrogen and 5.4 pounds protein increase for each ton. But it must not be concluded that this is the only difference. The roots with the tubercles rich in nitrogen possess greater fertilizing properties than the roots with no tubercles, the results of which would be shown in the succeeding crop or crops. Furthermore, had the tubercles been grown on poor soil instead of rich soil, doubtless there would have been a still greater difference in favor of inoculating.

Data as to Yield.—Plats C and F, not treated, remained green longer than the inoculated plants, which tended to increase their fodder yield in comparison with the others. The results show that the Yellow Soys, plat B, inoculated with extract, yielded a little the best of both grain and fodder, but the difference is very slight. Of the Medium Green, plat F, not treated, yielded the most grain, and plat D, inoculated with soil, the most fodder. In all these cases the differences are not great, and, as the plats were very small, it would be impracticable to pass any judgment as to comparative yield. The benefits from inoculation lie largely in the increased fertility of the soil resulting from the decay of the nitrogenous roots, and would not be seen until after the growth of the succeeding crop.

EXPERIMENTS IN THE GREENHOUSE.

Repetition and Extension of Field Experiment.—Pots containing native soil were planted to beans, and treated in the same manner as in the field experiment, and were attended with practically the same results. The test, in this case, was extended so as to include other varieties of the soy bean, namely: The Edamame, Kiyusuke Daidzu, Yamagata Cha-daidzu, Early White, and the Medium Black. In all these cases, where the plants were inoculated with either soil or extract, numerous and well-defined tubercles appeared on the roots. In a few instances, however, one or two tubercles were found on the plants not treated, but these were isolated cases, and were undoubtedly due to infection resulting from the manipulation of tools and pots when the beans were planted.

How Soon Do the Tubercles Appear?—To obtain information on this point, a small bed was planted in the greenhouse June 19 and inoculated with Massachusetts soil, from which plants were taken up nearly every day to ascertain when the tubercles began to appear. They were first visible to the naked eye on July 3, thirteen days after the beans were planted, or eight days after they appeared above the ground. From this it would be inferred that the bacteria began their work very soon after the young roots are formed and increase their activity with the growth of the roots.

Effect of Sterilizing the Soil—Pots of both Kansas and Massachusetts soil were sterilized by heating them to 200 degrees C. (392 degrees F.) The results obtained, both in the field and in pots, as well as by previous experience, showed that, as far as the soy bean organism was concerned, the Kansas soil was already sterile. In the case of the Massachusetts soil, however, these results show that the bacteria were killed at the above temperature, and plants grown in this soil produced no tubercles except when inoculated. It might be well to state in this connection that the heating of the soil produced other effects than those of a bacteriological nature, and the plants grown in it did not possess a healthy and vigorous appearance.

Plants Grown in Pure Massachusetts Soil.—(1) Since one-twentieth of a pint of Massachusetts soil was capable of producing such good results, both in the field and in pots, it was thought that plants grown in this soil alone would give still more striking results in tubercle formation. One pot each of Yellow Soy and Medium Green were grown in Massachusetts soil. The plants did well, and ranked among the best in the greenhouse, but on washing out the roots the tubercles were found to be only moderate in size, but fairly well distributed over the roots. In fact, they did not show up so well as plants which were inoculated with only a small portion of Massachusetts soil.

(2) Fearing the results obtained in the above experiment might be due to local conditions or disturbances, the subject was further tested by planting Yellow Soy beans in seven pots of pure Massachusetts soil and comparing with these seven pots of Kansas soil, all of which were inoculated with one-twentieth of a pint of Massachusetts soil. The results obtained were similar to those of the previous experiment, only that no appreciable difference could be seen in the results of the two treatments. Why a soil so thoroughly infected with micro-organisms as was this Massachusetts soil should not cause greater development of tubercles is a question not readily answered, and will bear further investigation.

Inoculating with Different Amounts of Massachusetts Soil.—To test the effect of varying amounts of Massachusetts soil on the number and size of tubercles produced, ten pots of Yellow Soy beans were grown, in which the soil had been inoculated with one-twentieth of a pint of Massachusetts soil for pot 1, two-twentieths for pot 2, and so on, increasing one-twentieth of a pint for each succeeding pot, until the tenth pot was reached, which received ten-twentieths or one-half pint of Massachusetts soil. No particular difference could be detected in the growth of the plants, and what was true of the upward growth was likewise found to be true of the roots and tubercles. The differences were slight, and these so irregular, that it could not be said that one was any better than the others. These results, taken in connection with those obtained from pure Massachusetts soil, seem to indicate that the micro-organisms are sufficiently numerous and active for ordinary inoculating in a comparatively small amount of the Massachusetts soil, and that an increase of this infectious soil does not perceptibly increase the number or size of the tubercles.

Inoculating at Top, Middle and Bottom of Pot.—To test the rapidity with which the organisms spread in the soil, three pots each of Yellow Soy and Medium Green were inoculated at the top, middle and bottom of the pots, respectively, with one-twentieth of a pint of Massachusetts soil. The washing out of the roots revealed the fact that the plants inoculated at the top of the pot produced tubercles on the upper portion of the roots, with only a few extending downward, and none on the lower portion of the roots. The plants inoculated at the middle of the pot produced tubercles about midway between the upper and lower portion of the roots; and, lastly, the plants inoculated at the bottom of the pot showed the tubercles on the lower portion of the roots, with a few tending upward. This is a very interesting point, and indicates that, without mechanical mixing, the micro-organisms spread very slowly in the soil, and that in spite of the fact that the plants were frequently watered on upper surface of pot, which one might suppose would have carried the bacteria deeper into the pots. The number and position of the tubercles are shown in the accompanying drawings. (See plates IV, V, and VI.)

Inoculating with Kansas Soil.—Will soil which has once been inoculated serve to inoculate non-infected soils? First, five pots were filled with soil taken from the immediate vicinity of roots previously inoculated. Second, five pots were filled with soil which had been soaked and washed out from plants that had produced tubercles in the field. Since nearly a two-foot cube was taken up with each hill, the number of micro-organisms must have been less in this instance than in the first five pots. Tubercles were produced in all the pots, but

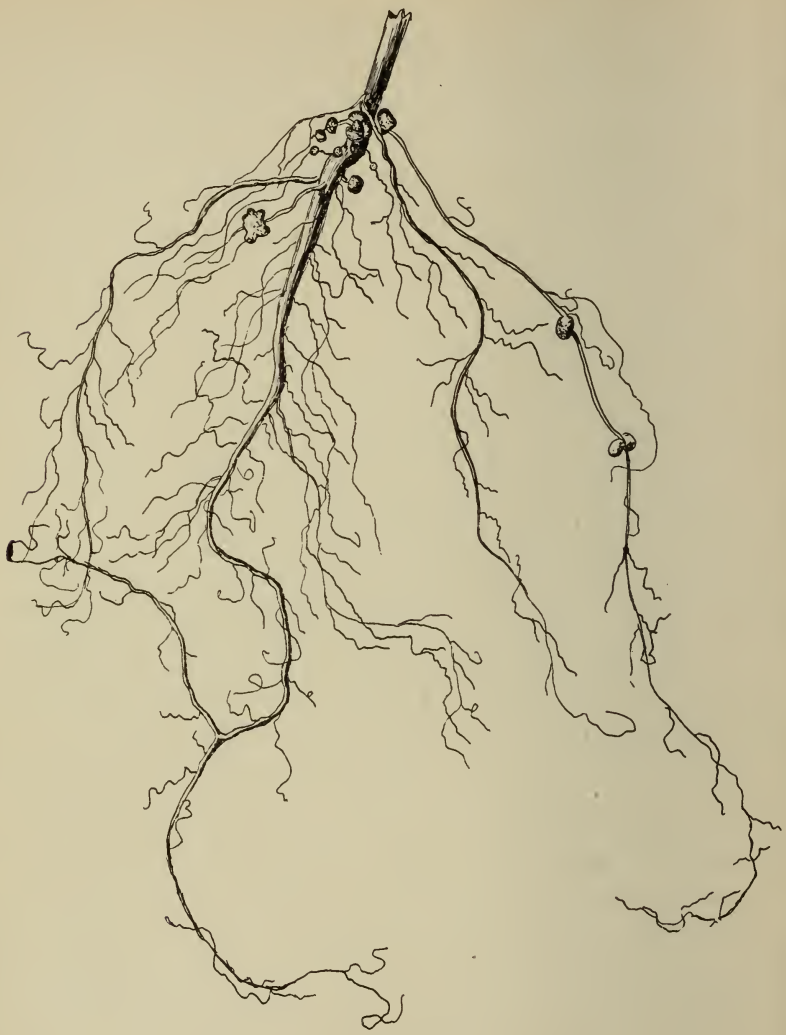


PLATE IV. Inoculated at top of pot.

the results, as might be expected, were somewhat more in favor of the first five. To test this matter still further, two pots were inoculated, each with one-twentieth of a pint of the above classes of soil, with the result that in both cases tubercles were shown in the same relative proportion to the above. This shows that Kansas soil, being once inoculated, can be used to inoculate other soils.

Inoculating with Tuberculous Roots.—After remaining in loose soil about a month, some of the roots which had previously produced tubercles were taken to inoculate a pot of Yellow Soy beans. The

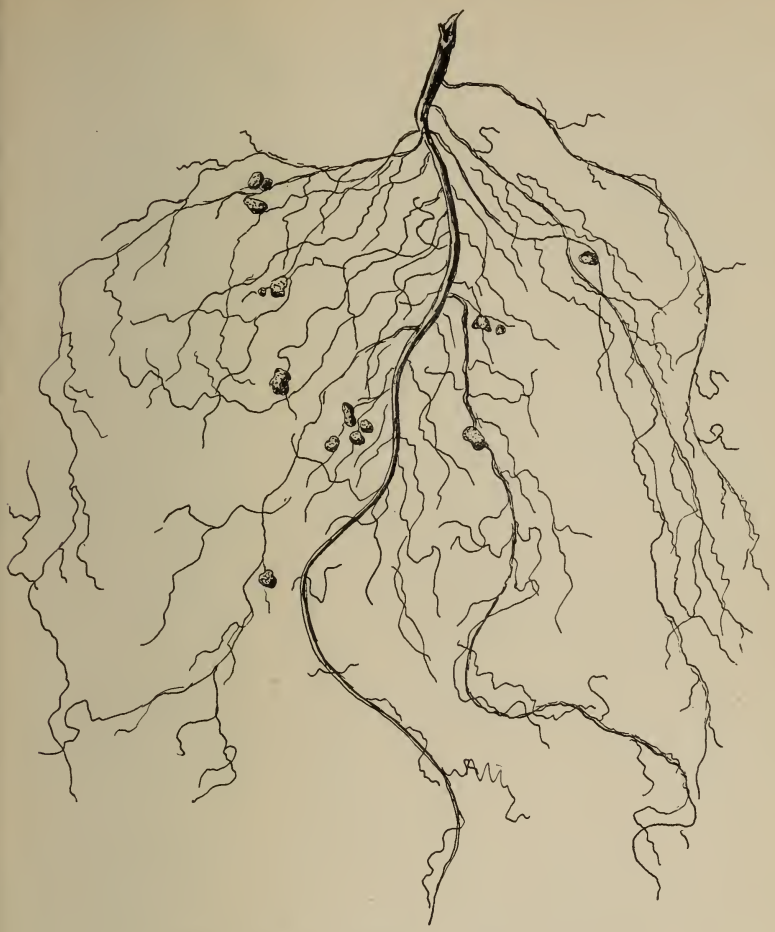


PLATE V. Inoculated at middle of pot.

plants grew well and ranked among the best in the greenhouse. On washing out the roots, large and numerous tubercles were discovered, which were by far the best of any produced in the greenhouse during this experiment. Likewise, washed roots that had been air dried in diffused light for about the same time were placed in another pot. Tubercles were formed but neither the growth of the plant nor the tubercles were equal to the above. In the former case the roots had more or less soil adhering to their surface, but in the latter there was practically none.

Effect of Inoculating Other Legumes with Massachusetts Soil.— Four pots each of the Adzuki beans (*Phaseolus radiatus*), cow-peas, Canada field peas, alfalfa, and Red clover were planted, half of these

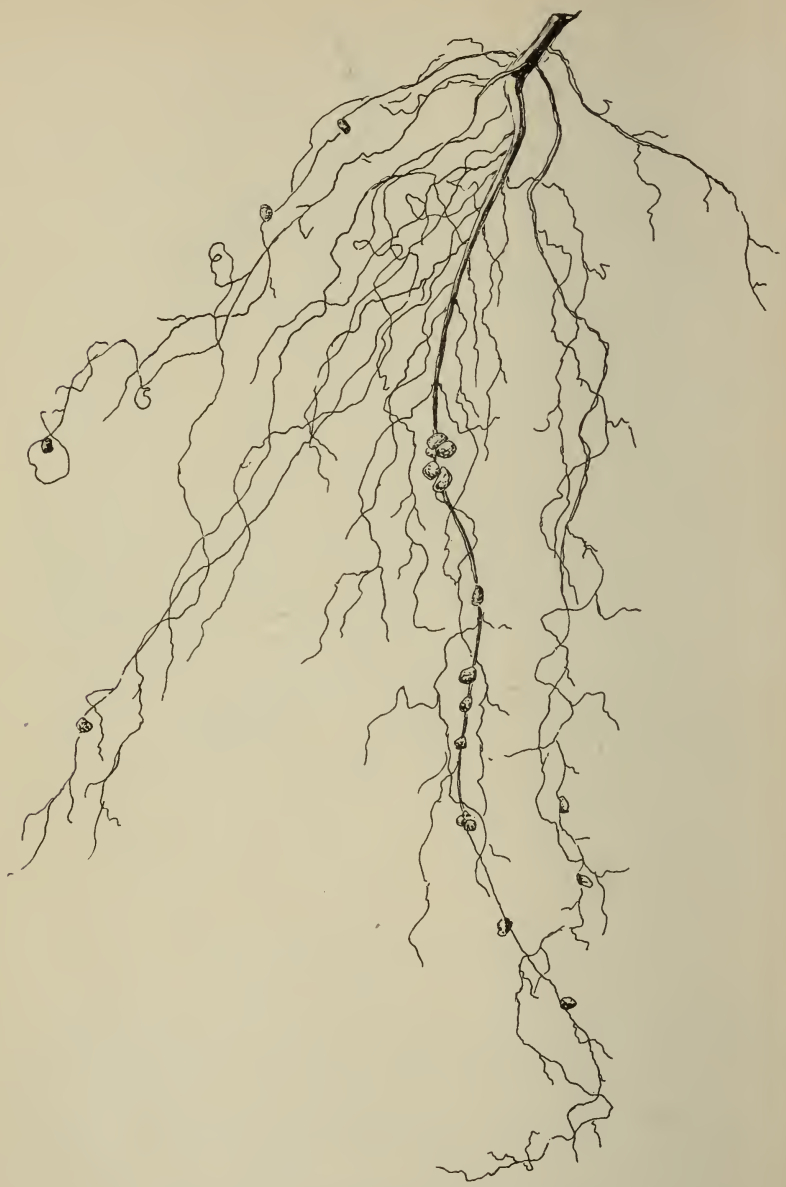


PLATE VI. Inoculated at bottom of pot.

being inoculated with Massachusetts soil and the other half not treated. On the roots of the Adzuki beans and the cow-peas, no nodules were apparent in any of the pots; the alfalfa showed several, and on the clover and Canada field peas they were very numerous, but no difference could be detected on any of them that was due to the Mas-

sachusetts soil. Evidently these plants were attacked by a different kind of organism than that attacking the soy bean.

EXTENT OF SOY BEAN MICRO-ORGANISM IN THE UNITED STATES.

After the success of inoculating the beans with imported soil was assured, it was thought to be an interesting point to ascertain how far these particular micro-organisms had spread in this country. Accordingly inquiries were sent out to all the experiment stations of the United States and the following table constructed from the replies:

Table II.

Micro-organisms indigenous to the soil.	Micro-organisms obtained through inoculation.	No tubercles found on the roots.	Have made no examination for root tubercles.	Too cold to successfully grow the soy bean.	Have not grown the soy bean.
Indiana. Louisiana. Mass. [Hatch]. North Carolina. Rhode Island. Tennessee.	Conn. [Storrs]. Kansas.	California. Florida. Iowa. Michigan. South Dakota.	Arizona. Arkansas. Colorado. Conn. [State]. Georgia. Illinois. Maryland. Missouri. Mississippi. Nebraska. New Jersey. N.Y. [Cornell]. N.Y. [State]. Ohio. Texas. Vermont. West Virginia. Wisconsin.	Minnesota. Washington.	Kentucky. Maine. Montana. Nevada. Pennslyvania. Utah. Virginia. Wyoming.
6	2	5	18	2	8

CONCLUSION.

The above experiments were not planned with a view to obtain comparative results as to yields. The main object was to ascertain whether or not a leguminous plant could be made to produce tubercles by inoculating with the soil impregnated with the right kind of micro-organisms. As the Kansas soil contained none of these organisms, the conditions were entirely under control, and results obtained which otherwise would have been impossible. The results show conclusively that inoculation is entirely possible; and this, taken in connection with the fact that it has been repeatedly proven that tubercles are valuable adjuncts to leguminous plants, both for yield and as a fertilizer, suggests the practicability of inoculating fields deficient in micro-organisms that would be beneficial to the particular leguminous crop to be grown. When we realize that in the Eastern states many farmers are paying from six to ten dollars an acre for fertilizers, which, in the aggregate, amount to a tax of millions of dollars, and as we in the West are fast tending in the same direction, should it not behoove us to lay hold of one of nature's most effective means of maintaining

and even increasing the fertility of the soil? Free nitrogen is around and about us in superabundance; it composes four-fifths of the air; but, without the aid of these bacteria working within the tubercles of the roots, plants have no power to make use of it. By growing leguminous crops in rotation, and inoculating the soil when the latter is deficient in the proper species of bacteria, and thus controlling the action of these microscopic plants, the farmer may find them to be among his best friends and strongest financial supporters.

Field Work in Soil Inoculation for Soy Beans.

H. M. COTTRELL, M. S., Agriculturist.
D. H. Otis, M. S., Assistant in Dairying.
J. G. Haney, B. S., Assistant in Field and Feeding Experiments.

The experiments made by Mr. Otis demonstrated that Kansas soil does not contain the bacteria which form tubercles on the roots of the soy bean, and that these bacteria can be introduced by the use of infected soil. In 1898 and 1899 the Farm Department made experiments to develop methods of inoculating soil that would be practicable in large fields under ordinary farm conditions.

FIRST EXPERIMENT.

Two acres were planted in the spring of 1898 to Early Yellow soy beans. The beans were planted in drills, with rows thirty-three inches apart, and the two acres were divided into sixteen plats. The inoculated soil used in this experiment was taken from a plat inoculated in 1896 with soil from the Massachusetts Experiment Station, and on which soy beans had been grown in 1896 and 1897.

This inoculated soil was taken up and dried until it would crumble easily and then applied as indicated. Inoculated water was made by soaking for three days half a bushel of inoculated soil in two-thirds of a barrel of water. Soy beans were placed in a sack and immersed in this water until thoroughly wet and then planted. Soy beans were mixed with the infected mud in this barrel, allowed to drain, and were then planted. On other plats the infected soil was applied as shown in the table.

Twenty average plants from each plat were carefully dug up, the soil washed from the roots, and the tubercles counted. The treatment given the plats and the results shown by this count are as follows:

	Tubercles on twenty plants.	Plants having tubercles.
1. Not inoculated; two plats	0	0
2. Beans inoculated in water	2	2
3. Beans inoculated in mud	2	2
4. Beans drilled with 150 pounds infected soil per acre	9	4
5. Beans drilled with 375 pounds infected soil per acre	35	5
6. Beans drilled with 750 pounds infected soil per acre	21	8
7. Infected soil broadcast before seeding, 100 pounds per acre	0	0
8. Infected soil broadcast before seeding, 500 pounds per acre	1	1
9. Infected soil broadcast before seeding, 1000 pounds per acre	1	1
10. Infected soil broadcast after seeding, 100 pounds per acre	1	1
11. Infected soil broadcast after seeding, 500 pounds per acre	2	1
12. Infected soil broadcast after seeding, 1000 pounds per acre	7	5
13. Infected soil drilled on top of row after planting three plats, 150, 375 and 750 pounds infected soil per acre	2	1

In this trial the only satisfactory results were obtained by drilling the infected soil with the seed.

In a plat inoculated with Massachusetts soil two years before, twenty plants bore 136 tubercles, one plant bearing thirty-five, and only one plant not having any tubercles. In another plat, inoculated Massachusetts soil was spread thickly in the bottom of the drill furrow, and the seed dropped in it. Twenty plants in this plat bore 509 tubercles on their roots, one plant having seventy-one, another sixty-nine tubercles, and only one plant not having any.

SECOND EXPERIMENT.

At the time the plats in the first experiment were planted, 11½ acres were planted to soy beans in another field. The entire field was treated, before planting, with inoculated soil sown broadcast at the rate of 1000 pounds per acre. The inoculated soil was distributed by hand from wagons as evenly as possible, and then mixed with the soil of the field by a disk harrow. The soy beans were planted in rows thirty-three inches apart.

A careful examination of hundreds of plants on this field failed to show a single tubercle, and this method, with the quantity of soil used, is a total failure.

THIRD EXPERIMENT.

The first and second trials convinced us that, to secure satisfactory results, the inoculated soil must be placed in contact with the seed as the seed lies in the ground, that the young roots may come in contact with the tubercle-forming bacteria as soon as possible.

We were anxious to develop a practicable method of securing this result the first year the trials were made, and after oats had been harvested from a field it was plowed and planted to soy beans. We had only an ordinary two-horse grain-drill. We put the beans in the grain box, stopping up all the holes but two, so as to make the rows the proper distance apart. A box was placed on top of the drill to

hold the inoculated soil. The drill planted two rows of beans. We took two large tin funnels, connected them with the drill holes by rubber tubing, and poured the inoculated dirt into these funnels with scoops. The team was driven slowly, and we could watch the inoculated soil and the beans falling together into the drill mark, every bean being thoroughly surrounded with the inoculated soil. The method was crude, but it put the inoculated soil and beans where we wanted them.

The beans were planted July 21, 1898, and 611 pounds of inoculated soil from the Massachusetts Experiment Station was drilled in with the beans on half an acre.

The result of this trial was all that could be desired. In ten days after the bean plants appeared above ground tubercles could be found on their roots, and when the plants became full grown the roots were thickly studded with tubercles.

EXPERIMENTS IN 1899.

In the spring of 1899 we purchased a grain-drill having a fertilizer attachment. Inoculated soil was taken from the rows of beans grown in the third experiment of 1898, spread on boards in the field until it became well dried, and was then powdered. The drill was set to sow 600 pounds of fertilizer per acre; all the holes were stopped except those connected with the spouts from which the seed was being dropped. The drill planted the seed and mixed the inoculated soil with the seed as fast as the team could walk. We inoculated forty-six acres of soy beans. The results were satisfactory, nearly all plants bearing a large number of tubercles.

PROFITS FROM INOCULATION.

Kansas farmers should raise soy beans because of their value as feed, and the benefits from inoculation give an extra profit. Soy beans are richer in flesh-, blood-, milk- and bone-making material than linseed-meal. They can be raised at a cost of thirteen to eighteen dollars per ton, and, pound for pound, are worth a little more than linseed-meal for fattening steers and sheep and in feeding dairy cows and young stock. In experiments made at this Station, soy beans, fed with Kafir-corn and corn in fattening hogs, made a saving in the amount of feed required to make 100 pounds of gain of from thirteen to thirty-seven per cent. Besides these qualities, soy beans stand drought as well as Kafir-corn or sorghum and are not touched by chinch-bugs.

The yield of crops of all kinds is increased where they follow soy beans, wheat showing in large fields an increase of five bushels per acre when following soy beans over that grown on adjoining land that

had not been in beans. This increase is shown where soy beans bearing no tubercles have been grown. Where no tubercles grow on the roots the soy bean does not add fertility to the soil but simply makes available for other crops the plant-food already in the soil. The soy bean is a strong feeder and can obtain plant-food from the soil that a weaker plant like wheat is unable to secure. Then, when the beans are harvested, their roots decay and the plant-food in them is in such a condition that wheat or other ordinary farm crops can easily use it.

Inoculated soy beans add plant-food to the soil. Nitrogen is one of the most needed elements of plant-food. The reduced yield from our long cultivated fields comes chiefly from the lack in the soil of nitrogen in a form which our field plants can use. Four-fifths of the air is pure nitrogen but ordinary plants can make no use of it. The bacteria that cause and live in the tubercles on soy-bean roots take this nitrogen from the air and put it in such a condition that our ordinary field plants can use it. In this way inoculated soy beans, while yielding a profitable grain crop, make the soil richer than before the crop was grown. Where the beans do not have tubercles no plant-food is added to the soil, but that already there is made available for the production of larger yields of crops following the soy beans, and in the end the land is made poorer.

INOCULATION FOR RENTERS.

Inoculation of the soil for soy beans is profitable for the farmer who owns his land. It is also especially adapted for the man who rents the land on which he raises crops. Most rented farms in Kansas are let from year to year. Alfalfa and clover usually require the loss of the use of the land for one year after seeding, and in many sections there is not a good market for the hay. This keeps the tenant from raising these crops; he grows one grain crop after another, and with slowly reducing yields and decreasing profits both to himself and the owner of the land. The renter can raise soy beans, inoculate the land, and have a profitable grain crop. The next year he can follow with any other crop desired. No time is lost, and only marketable crops need be raised.

If sufficient rain falls after harvest, soy beans may be planted after wheat or oats, and the ground inoculated and enriched without interfering with the regular crops.

HOW TO INOCULATE SOIL.

One hundred pounds of inoculated soil will be sufficient to start 500 feet of row for an inoculating bed. If a drill is not convenient, a shallow furrow may be opened by any convenient tool, the infected soil thickly spread along the bottom of this furrow, and the soy beans

dropped one to two inches apart in the row, and covered with the soil of the field in which the beans are planted. The plants growing in this row will be well supplied with tubercles. In harvesting, the soy beans are cut off just below the surface of the ground. This leaves the roots with the tubercles in the soil. In collecting the soil from this row, after the beans are harvested, take just a spade width in the row, and take up the dirt to a depth of four to five inches, going as deep as the tubercles extend. Spread this dirt on boards in the sun until it becomes well dried, and then sack it and store in a dry place. The soil from 500 feet of row will supply sufficient soil to infect several acres the second year.

Our experiments have not been conducted long enough to thoroughly test the matter, but it is probable that a field once inoculated will always remain inoculated, and that the bacteria will slowly increase in the soil. The bacteria live for a long time in the soil after the plants are removed. We have kept dry inoculated soil in sacks two years, where it became as dry as road dust, and it had full strength in producing root tubercles when used.

EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN No. 97—MAY 1900.

FARM DEPARTMENT.

H. M. COTTRELL, M. S., Agriculturist.
D. H. OTIS, M. S., Assistant in Dairying.
J. G. HANEY, B. S., Assistant in Field and Feeding Experiments.

SKIM MILK CALVES.

THE greatest drawback to the dairy industry in Kansas at the present time is the skim milk calf. Well-bred steer calves allowed to run with their dams until weaning time sell readily at twenty dollars to twenty-five dollars each, and the demand is greater than the supply. No labor is needed to raise a calf in this way, and the only expense is the cost of keeping the cow a year. When a cow grazes on prairie pasture through the summer and is fed through the winter on sorghum hay, stalk fields, and similar cheap feeds, this method of calf raising gives large returns with little labor and small expense.

A calf raised on skim milk needs care two to three times a day, although the time needed is short, and, with the usual method of handling, is a runt—thin, ill shaped, unhealthy looking, and sells for $7 to $12. The difference in value between such a calf and one allowed to run with the cow reduces the profits made from milking, and on this account there has been a large decrease in Kansas during the past eighteen months in the number of cows milked.

At the same time, there are Kansas farmers who raise calves on skim milk worth as much at weaning time as calves that run with their dams, and the agriculturist of this Station raised for years pure-bred calves on skim milk that were in condition for the show ring when six months old, and that sold at $75 to $125 each.

If a majority of the stockmen of this state could, without much expense for time, raise calves on skim milk worth as much, or nearly as much, at weaning time as calves following the cow, the dairy products of the state would soon be doubled and trebled. The experiments recorded in this bulletin were made to show how this can be done.

PLAN OF THE EXPERIMENT.

Thirteen calves from the College herd of scrub cows were used in this experiment. The plan was to use skim milk, and feed with it some grain to take the place of the butter-fat that had been removed for butter-making. The calves were divided into three groups, all having skim milk, and one lot fed Kafir-corn meal, one lot Kafir-corn meal and flaxseed meal, and one lot Kafir-corn meal and Blachford's calf meal.

Kafir-corn meal was selected because it can be grown cheaply on every Kansas farm; it is rich in starch, the material needed to take the place of the butter-fat, and it is a constipating feed. On this account, we thought it might overcome the loosening effect of the skim milk. Flaxseed meal was used because it is usually recommended by dairy writers as the best feed to give with skim milk. Blachford's calf meal was used because it was being extensively advertised at the time, and has been used for years by many successful calf feeders.

A test was also made with each kind of grain of feeding skim milk from the creamery and from the hand separator. The creamery skim milk used was sterilized skim milk obtained six times a week from the Manhattan creamery, and was the same quality as that supplied to their other patrons. The milk was sterilized by a Jensen sterilizer, in which the skim milk passes over a pipe from which steam is escaping from many holes. This method of sterilizing adds ten to twelve per cent. of water to the skim milk. The hand-separator skim milk was from milk separated as soon as drawn from our cows, and fed while warm to the calves.

The dates of birth of the calves fed in this experiment are as follows: December 4 and 28, 1898, and February 17 and 23, March 13, 14, 25, 28, and 30, and April 10, 15, 16, and 21, 1899. This gave both winter and spring calves for the trial.

J. A. Conover, College herdsman, fed the calves in this experiment, and the good gains made are due to his skill as a feeder.

FEED AND CARE OF THE CALVES.

The calf was allowed to run with the cow until the cow's udder became all right and her milk good—usually four to five days. The calf was then taken from the cow and left without feed for twenty-four

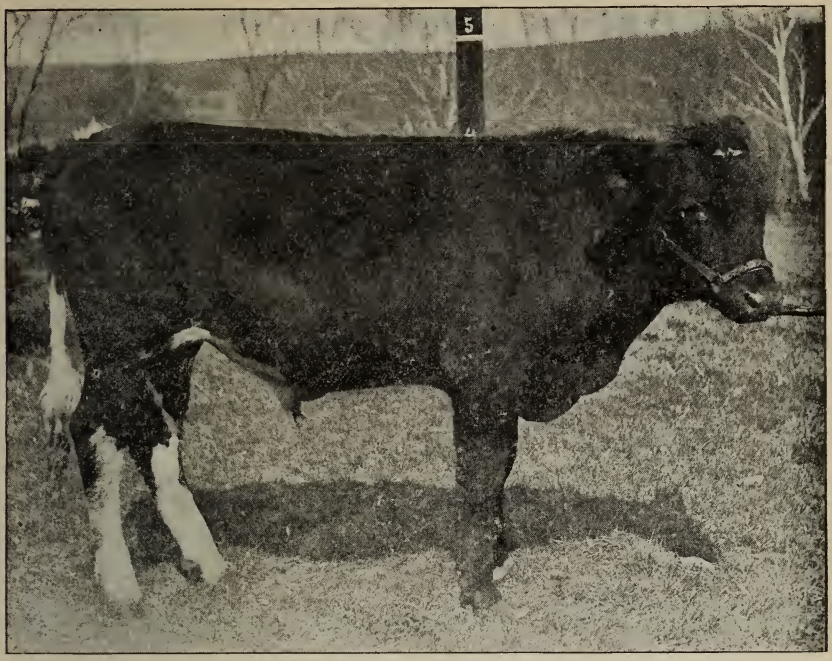


PLATE I. Skim Milk Steer.

hours, when it became hungry enough to be easily taught to drink. The first week a calf was given ten pounds of warm whole milk a day: four pounds in the morning, two pounds at noon, and four pounds at night. The second week the amount of milk fed was about the same, but it was given in two feeds, morning and night. In two or three weeks after being taken from the cow the calf was gradually put on skim milk.

At the first feed of skim milk, one pound (one pint) of skim milk was given; at the second feed, one and one-half pounds, and at the third, two pounds. As the skim milk was increased the whole milk was decreased, until the entire feed became skim milk, the change being made at the rate of half a pound per feed. The amount of skim milk fed was slowly increased as the calf could safely take it. At the end of a month from the time the calf was taken from the cow the daily amount given was usually from twelve to fourteen pounds per calf; at two months, eighteen pounds, and finally reached twenty-two to twenty-four pounds per day per calf.

A quart weighs a little over two pounds, so that the number of quarts fed was only half the number of pounds. This will seem a small amount to many feeders, but it was all that the calves could eat and thrive, and the gains made show that the quantity was sufficient.

Four of the calves were fed flaxseed meal. The meal was placed in a tin pail, boiling water poured over it, and the pail closely covered to keep in the steam. A jelly was formed, just enough water being used to do this. The jelly was mixed with the skim milk at the time of feeding. A tablespoonful of flaxseed per calf for a feed was used at first, and this was gradually increased to half a pound per day per head when the calves were three to four months old.

Four of the calves were fed Blachford's calf meal. The meal was mixed with water to form a gruel, according to directions sent with the feed, and the gruel was mixed with the skim milk. The amounts fed were the same as those for flaxseed meal.

All calves were fed Kafir-corn meal. It was fed DRY in boxes. The calves began to eat this meal when ten days to two weeks old. At first a handful was put in a calf's mouth as soon as he had finished drinking his milk, and he soon learned to eat with a relish from the feed-boxes. Never mix Kafir-corn meal or other grain with the milk. The calves were fed what meal they would eat up clean. Calves two months old would eat two pounds each of Kafir-corn meal a day.

When ten days to two weeks old the calves began to nibble hay, and were thereafter fed all they would eat, the hay being given fresh twice daily. If calves are troubled with scours prairie hay is best; if not, alfalfa is the best, and clover hay second. Before turning the calves on pasture we cut green alfalfa and fed it to them, beginning with a small quantity, and slowly increasing until the calves had all they would eat. A sudden change from hay to grass is almost sure to bring the scours.

All milk was fed warm, 95 to 100 degrees, and a thermometer was used frequently, to be sure that the temperature was right. The milk was fed sweet. The sterilized milk came from the factory very hot. At night that wanted for the evening's feed was cooled to blood heat and fed. The rest was cooled to the temperature of our well-water, fifty-eight to sixty degrees, and held at this temperature until fed, when it was warmed to blood heat. With few exceptions, the skim milk treated in this way would keep sweet from Saturday until Monday morning, and there was no difficulty in keeping it sweet for use through the week.

The milk was fed in tin pails, and these and the cans in which the skim milk was kept were thoroughly washed and scalded each time after using. They were then set in the sun when possible. The calves were kept from sucking each others' ears by being kept separate for half an hour after feeding, until their mouths became dry. This was done by tying them up. We are now doing it more conveniently and with less labor by putting them in stanchions, as shown in the cut

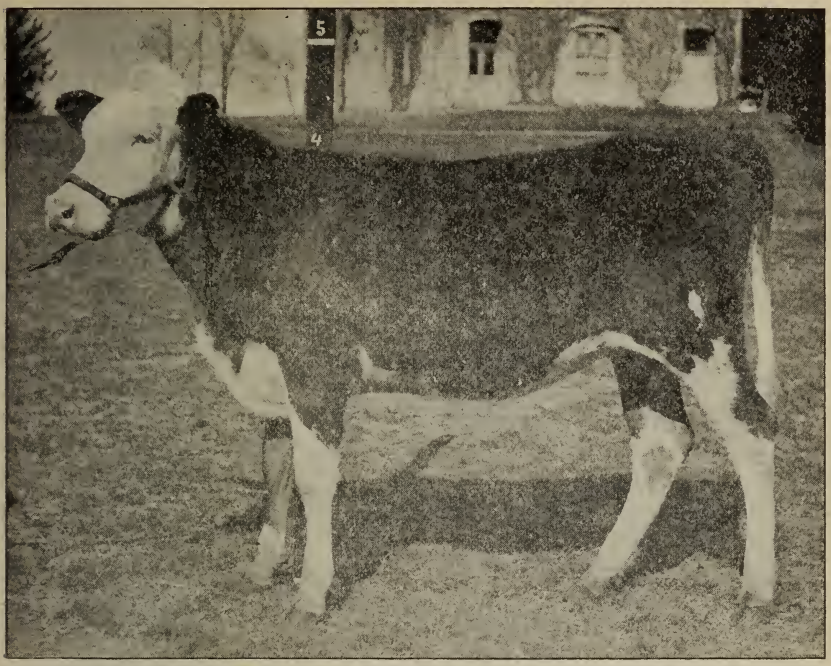


PLATE II. Skim Milk Heifer.

Fresh water was kept within reach of the calves all the time, and it was surprising to find how many times a day a calf would take a sip. The thirteen calves, when one to three months old, drank in seven days in June 868 pounds of water—9½ pounds per head a day. The calves were watered by attaching a Dewey hog-waterer to a barrel. This waterer kept only a small quantity before them, and, as soon as a drink was taken, fresh water flowed in, giving the calves fresh, clean water at all times. The barrel was kept covered.

As soon as the calves were taken from the cows they were dehorned. The hair on the place where the horn would appear was clipped off with shears, the end of a stick of caustic potash was wet in cold water, and the spot over the horn rubbed with it until the skin appeared raw. A light scab formed, soon to disappear, and the growth of the horn was prevented.

The steer calves were fed all the Kafir-corn they would eat. This was soon found to be too fattening for the heifers intended for dairy use, and their grain ration was changed to bran and oats, fed in such limited quantities as to keep them thrifty and growing, but not to make them fat.

The calves were sheltered in cold weather between two corn-cribs,

the space roofed, and they had an open shed in their pasture in summer where they could go for shade. The shelter and yards used by the calves were kept clean and lime was frequently sprinkled around them. The calves were closely watched, and if one began to scour his feed was at once cut down and he was given from one to two ounces of castor-oil. If this was not sufficient, ten to fifteen drops of laudanum a day were given in the milk, and usually the trouble stopped in two or three days. The calves were inoculated when two to four months old to prevent blackleg. They were treated kindly at all times and became pets.

RESULTS TO WEANING TIME.

We stopped feeding skim milk to the calves when they were about six months old. Nine heifer calves weighed at weaning an average of 375 pounds each, and four steer calves at weaning weighed an average of 383 pounds each. All were in good, thrifty condition, in good shape to go into the feed lots, and gave no indication of having been "hand fed."

Six calves were fed creamery skim milk, and made an average gain while on this feed of 250 pounds each. Seven calves were fed skim milk separated by the hand separator as soon as drawn from the cow and fed while yet warm. The calves fed hand-separator skim milk made an average gain while on this feed of 251 pounds each. The calves fed creamery skim milk ate an average of 2497 pounds each, while the calves fed milk from the hand separator consumed an average of 2504 pounds each. This is a rather remarkable showing, as the creamery skim milk contained ten to twelve per cent. of water added in the process of sterilizing.

The calves at first showed a strong dislike for the sterilized milk on account of its peculiar odor, but they soon became accustomed to this odor, and then drank with a relish. When the calves were first put on skim milk, those fed that from the hand separator were troubled more with scours than those having the sterilized creamery milk. Scalding the skim milk in sterilizing helped to overcome the tendency to produce scours. After a few weeks' feeding, no difference could be detected in the thrift of the calves having the different kinds of milk. So far as the growth of calves is concerned, it will not pay to buy a hand separator when good sterilized milk is sent out from the creamery.

Five calves which had nothing mixed with their skim milk gained 1.82 pounds each per day; four calves which had Blachford's calf meal mixed with their skim milk gained an average of 1.9 pounds each per day, and four calves which had flaxseed-meal jelly mixed with their milk gained an average of 1.55 pounds per day. Blachford's

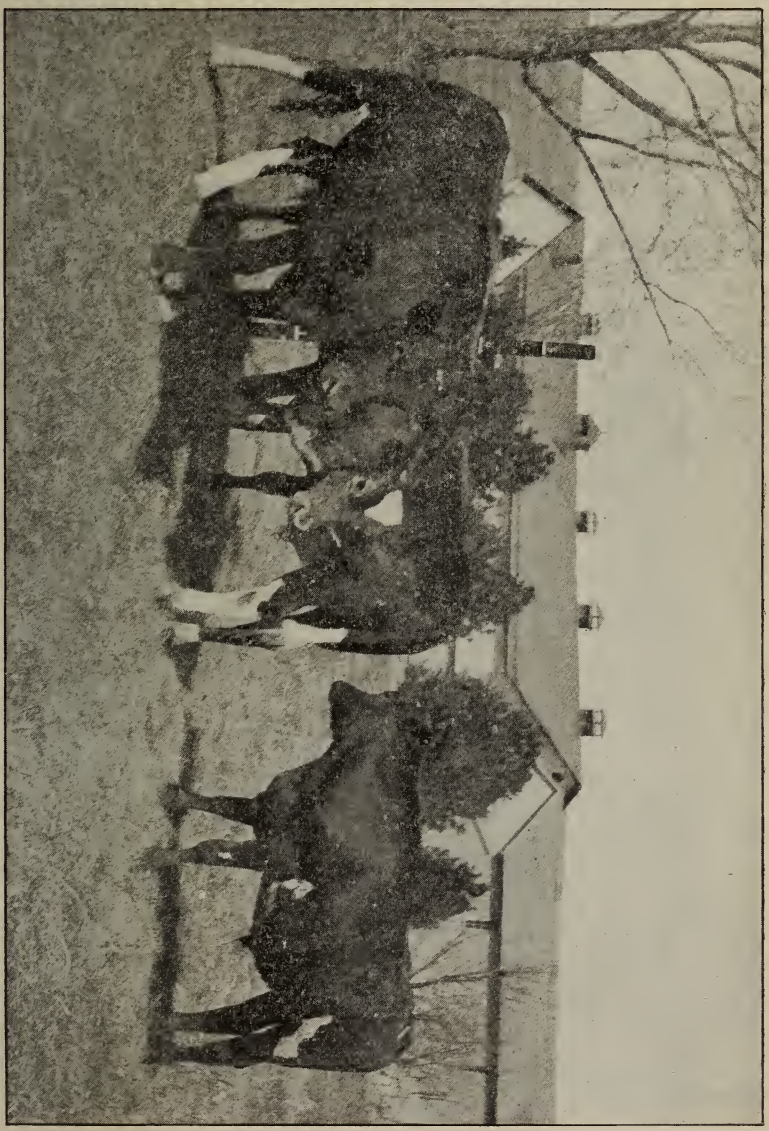


PLATE III. Skim Milk Steers. Average weight, 724 pounds, at one year old.

calf meal cost $70 per ton, and flaxseed meal $125 per ton. Neither paid, and this experiment shows that such expensive feeds added to skim milk are not only not profitable, but are useless, practically having no effect on the gain. All the calves were fed dry grain and hay separately from the skim milk, and were pastured during the warm months.

COST TO WEANING.

The thirteen calves, while on skim milk, gained 3260 pounds. They were fed: Skim milk, 32,511 pounds; Kafir-corn meal, 3476 pounds; corn-meal, 1872 pounds; soy-bean meal, 109 pounds; oil-meal, 74 pounds; grounds oats, 148 pounds; bran, 536 pounds; Blachford's calf meal, 136 pounds; flaxseed meal, 78 pounds; mixed hay, 466 pounds, and green alfalfa, 407 pounds. Kafir-corn meal was fed to all the calves for the first month, as we found it superior to any other grain. After the calves became older, corn-meal was used whenever it was more convenient to get it than the Kafir-corn. As before stated, we found that the Kafir-corn meal caused too great a gain with the heifer calves, and we were obliged to substitute bran, soy-bean and oil-meals, ground oats, and the other feeds mentioned.

Our record of gains made and feed consumed shows that, to make 100 pounds of gain in this experiment, there was fed: Skim milk, 997 pounds; grain, 197 pounds; hay, 14 pounds; green alfalfa, 12 pounds. Valuing skim milk at fifteen cents per hundred pounds, grain at one-half cent a pound, hay at three dollars a ton, and green alfalfa at one dollar a ton, reasonable prices on Kansas farms, 100 pounds of gain on these skim milk calves cost $2.50. The thirteen calves, while on skim milk, made an average daily gain of 22.8 pounds. It required two hours a day to feed and care for them. At twelve and one-half cents per hour, this would cost twenty-five cents a day. This would make the cost of labor $1.10 per hundred pounds gain, and the total cost of feed and labor $3.60 per hundred pounds gain.

Did it pay us to milk? The calves made as good gains as they would if we had let them run with the cows. The $3.60, cost of 100 pounds gain, was the additional cost caused by milking, and must be deducted from the amount received from the sale of the milk. Nine hundred and ninety-seven pounds of skim milk were required for each 100 pounds of gain. We sold 45.7 pounds of butter-fat from the whole milk needed to make this amount of skim milk. The creamery paid an average of 15 cents a pound for the butter-fat, making the 45.7 pounds worth $6.86. Deducting $3.60 from this, we have $3.26 left as the returns for the labor of milking and delivering 1100 pounds of milk to the creamery. If all the calves had been intended for beef, we could have fed Kafir-corn as the only grain and increased the gain.

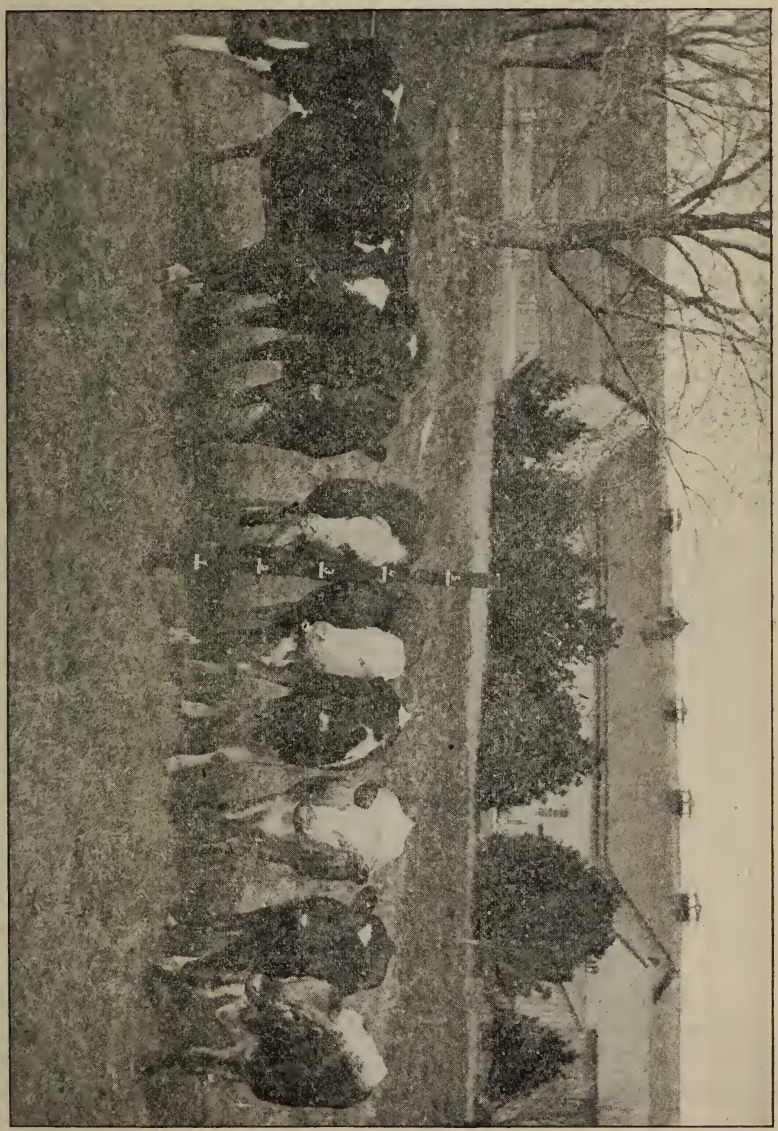


PLATE IV. Skim Milk Heifers, raised for the Dairy. Average weight, 564 pounds, at one year old.

AS YEARLINGS.

The four steer calves weighed an average of 724 pounds each when one year old, and the nine heifer calves weighed an average of 564 pounds each at one year old. The heaviest steer weighed 810 pounds. These calves were all from scrub cows, and for this class of cattle show good weights.

The calves were weaned when six months old. From weaning to a year old the steers made an average gain of 341 pounds each, an average of 1.89 pounds each per day. The steers were not pushed, but were fed to make good growth. The feed was Kafir-corn grain, corn-fodder, sorghum hay, and alfalfa hay. The heifers were intended for the dairy. They were given the same kinds of feed as the steers, but much less in quantity, as we wanted to keep them from the habit of putting on fat. The nine heifers made an average gain of 189 pounds each from weaning time until a year old, an average of one pound of gain a day each.

The calves were in good condition to go into the feed lots when weaned, and at that time we were offered twenty to twenty-two dollars per head for the steers. The gains made after weaning are greater than those usually made after weaning by calves that have run with the cows. The skim milk calves have the advantage that at weaning time they are already on feed, and do not suffer the check that comes when a six-months'-old calf is weaned and put on dry feed.

In the six months after weaning, the four steers were fed an average per steer of Kafir-corn meal, 677 pounds; corn-meal, 209 pounds; soy-bean meal, 90 pounds; oil-meal, 15 pounds; bran, 41 pounds; corn-and-cob meal, 347 pounds; tame hay, 425 pounds; alfalfa hay, 694 pounds; Kafir-corn fodder, 832 pounds; green sorghum, 21 pounds.

In the six months after weaning, the nine heifers were fed an average each of Kafir-corn meal, 185 pounds; corn-meal, 71 pounds; soy-bean meal, 76 pounds; oil-meal, 7 pounds; bran, 130 pounds; corn-and-cob meal, 108 pounds; wheat, 20 pounds; cow-pea meal, 10 pounds; tame hay, 402 pounds; alfalfa hay, 432 pounds; Kafir-corn fodder, 985 pounds; green sorghum, 27 pounds.

CREAMERY SKIM MILK.

In our trial creamery skim milk gave a little better returns than that from the hand separator. This is not generally the case, and a large number of creamery patrons claim that skim milk from the creamery is often unfit to feed by the time that it has reached the farm, and that, even when it is not spoiled, it is difficult to keep it sweet until morning or over Sunday. Our creamery skim milk was secured from the Manhattan creamery and was sterilized at the creamery as fast as separated.

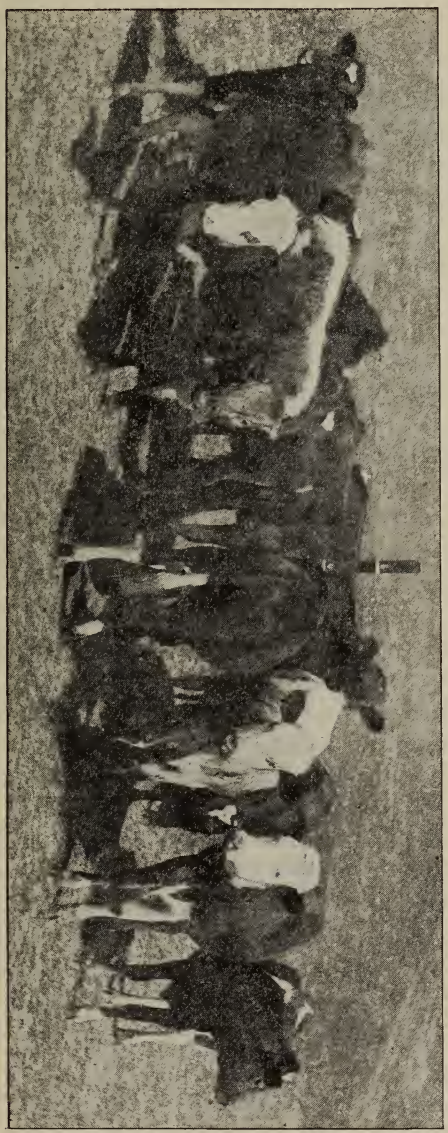


PLATE V. The thirteen Skim Milk Calves fed in this experiment.

Skim milk sterilized can be kept sweet forty-eight hours in the most unfavorable weather with the care that can be afforded by every dairyman. To become sterilized, milk must be heated to boiling, 212 degrees. If heated to a lower temperature the skim milk sours quickly, in many cases apparently more quickly than if not heated at all. In several skimming stations in the state we found an attempt made to sterilize the skim milk with a jet pump, this being used to elevate the skim milk from the separator to the skim milk tank. In every case the milk soured quickly, the method was abandoned, and sterilizing declared to be a failure. The trouble was that the jet pump did not heat the milk hot enough to sterilize it.

Every creamery patron should insist that the creamery should sterilize the skim milk. After patrons have induced their creamery man to sterilize the skim milk, they usually in a week or two want the sterilizer taken out, as, on account of the peculiar cooked odor, calves do not like sterilized milk at first. The calves soon learn to like it and the creamery man should keep on sterilizing.

Sterilizing the skim milk has many advantages besides improving the keeping quality of the milk. The milk taken to the creamery must be pure and sweet or the skim milk cannot be sterilized. A single can of sour milk in the sterilizing vat will spoil all the milk put in that vat during a run. For this reason, where skim milk is sterilized, the patrons must deliver pure, sweet milk only, and not a can of tainted or sour milk can be accepted. This insures a better quality of butter than if some tainted milk is received, and both patron and creamery man get more from their sales. It is easier to keep whole milk sweet on the farm when the creamery sterilizes the skim milk. The boiling-hot sterilized skim milk is put in the patron's can and the heat immediately kills all the germs in the can that might otherwise sour the new milk at the next milking. The women of the farm report from all parts of the state that they have much less work in keeping milk cans clean where the skim milk is sterilized, as the boiling skim milk gives the cans a thorough scalding.

The creamery skim milk used in this experiment was sterilized by the Jensen sterilizer, the invention of A. Jensen, Manhattan, Kan. This sterilizer is the only successful one we have found in operation in Kansas.

Sterilized skim milk is very hot when it reaches the farm, even though the farm be a long distance from the creamery. That part of the skim milk which is to be fed at night may be left untouched until feeding time, when, if too warm, it should be cooled to blood heat. That part of the skim milk intended for the next morning's feed, or that which is to be kept over Sunday, should be cooled to the tempera-

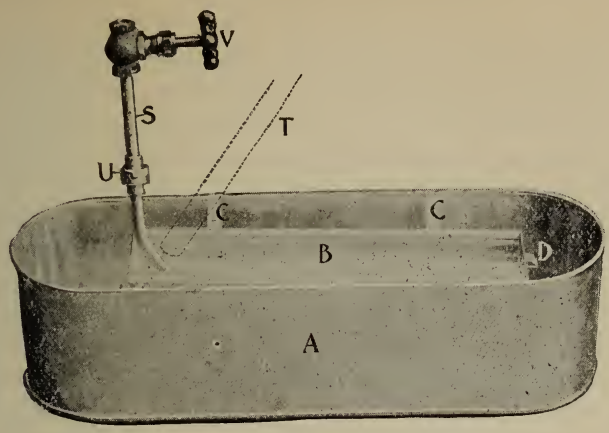


PLATE VI. Jensen Sterilizer.

A represents the skim milk tank; B is a shallow metal trough, placed in the skim milk tank in such a way that the milk overflows at outlet D. A steam-pipe, S, curving at U, runs along the bottom of the trough, and is perforated with many holes. The skim milk from the separator enters the upper end of the trough through pipe T and flows over the perforated steam-pipe and becomes sterilized. Valve V regulates the steam.

ture of well-water, and kept cool until fed. This may be done by setting the can of skim milk in a trough or barrel of cold water and putting a wet bran bag over the top. The milk should be warmed to blood heat just before it is fed.

HOW TO RAISE A SKIM MILK CALF.

Nature's way of raising a calf by allowing it to run with the cow produces a good one—the kind feeders want; and the dairyman must provide, as nearly as possible, the same conditions for the calf as it has when with its mother, and he, too, will produce the calf demanded by the feeder.

The cow feeds the calf often, with milk that is blood warm, sweet, and free from germs. Leave the calf with the cow until her udder gets in good condition and her milk all right. This gives the calf the same treatment at the start that he gets if he is to stay with the cow all the time until weaning. If the cow's udder is hard and feverish, rubbing it by the calf's baby head in his attempt to get food reduces the swelling and softens the udder. For about two weeks after the calf is taken from the cow, the best results are obtained by feeding warm whole milk three times a day—two quarts in the morning, one quart at noon, and two quarts at night. After this the calf will do well if fed only twice a day, morning and night, at regular hours. At the end of three weeks, begin to get the calf on skim milk, but do this gradually. The first time, take out half a pint of whole milk and put

in its place half a pint of skim milk; the second feed, use a pint of skim milk and take out a pint of whole milk. This method takes ten days to change from whole milk to skim milk. Increase the amount of skim milk fed slowly as the calf can take it, remembering that ten to twelve quarts of skim milk is a full feed for a calf five to six months old.

The cow supplies the milk to the calf blood warm. Feed both whole milk and skim milk at this temperature. We feed all skim milk warm, even when the calf is five or six months old.

The cow's milk contains all the materials needed for the health and growth of the calf in just the right proportions. Skim milk is without the cream or fat, and must be balanced up. Feeding trials have shown that starch in food takes the place of fat, and serves the same purpose when eaten. It is the dairyman's business, then, to take high-priced butter-fat from the milk, sell it, and supply in its place to the calf a cheap food, rich in starch. Corn is good for this purpose; Kafir-corn grain is better. Calves fed skim milk have a strong tendency to scour; Kafir-corn is rich in starch, and is our most constipating grain. It seems to be adapted by nature to be fed with skim milk, the two together producing the natural condition of the bowels. We feed Kafir-corn finely ground to calves, and always feed it dry, separately from the milk. More skim milk calves are probably stunted or killed outright in Kansas by mixing the grain with the milk than by any other means.

Calves need starchy grains to take the place of the butter-fat taken out of the milk. Starch cannot be used to support life until it has been changed to sugar. The saliva of the mouth has the power to change starch to sugar and the more slowly and thoroughly the grain is masticated the better it will be mixed with the saliva and the greater the proportion of starch that will be changed to sugar. Feed dry Kafir-corn meal or other grain to the baby calf and it will chew and chew for a long time on a small quantity of the grain, getting the starch thoroughly mixed with the saliva. Mix the grain with the milk and it is quickly eaten and swallowed, little saliva is mixed with it, and but little starch is changed so that it can be used by the body. The rest not only does the calf no good, but irritates the system, bringing on indigestion and scours and stunting the calf. Feed grain dry.

Keep the calves separated after feeding milk until their mouths become dry, so that they will not suck each others' ears. Where a number are fed, this is most easily and cheaply done by light stanchions, which can be made out of fence boards and set up in the feed yard or pasture, or other convenient place.

PLATE VII. Skim Milk Calves in a Stanchion.

The calf will begin to eat grain and hay when ten days to two weeks old. These feeds should be given fresh twice a day. Prairie hay or timothy is best for young calves; alfalfa or clover for older ones.

A supply of fresh clean water should be kept within reach of the calves all the time. The most convenient way of providing this is with a hog waterer, attached to a barrel as previously described. Have salt where the calves can eat what they want of it.

The greatest difficulty in raising skim-milk calves comes from scouring. Prevention is easier than cure. The chief causes are overfeeding, feeding cold or sour milk, feeding grain with the milk, and dirty pails and feed-boxes. Careful watching will usually prevent any serious trouble from this disease. At first indications, immediately cut down the feed. Milk pails and cans should be washed and scalded, the same as if the milk was intended for the table. For scouring, give one to two ounces of castor-oil, or, if the case is bad, ten to fifteen drops of laudanum a day, until the trouble is checked. Change feeds very slowly, as a sudden change often causes scours.

Finally, remember that the calf is a baby and give it the kindness and care due every baby. The better a calf likes you the more it will gain. Pet it. Keep its pen and yard dry and comfortable; keep it warm in cold weather and give it cool shade in summer. We like

a shed open on all sides for summer shade, as this will protect from the sun and allow the air to blow through freely. The College has a large stone barn with basement, but we found that our calves thrived better in a common board shed than they did in this barn. The basement was not as well lighted and ventilated as the shed.

Flies often annoy calves so that they do not gain well. The department of horticulture and entomology of this Station furnished us a formula that we used on the calves in this experiment at a cost of one-fourth to one-half cent a day and kept the flies off. It is as follows: Pulverized resin, 2 parts, by measure; soap shavings, 1 part; water, ½ part; fish-oil, 1 part; oil of tar, 1 part; kerosene, 1 part; water, 3 parts. Place the resin, soap shavings, ½ part of water and fish-oil together in a receptacle and boil till the resin is dissolved; then add the 3 parts of water, following with the oil of tar mixed with the kerosene. Stir the mixture well and allow it to boil for fifteen minutes. When cool, the mixture is ready for use, and should be stirred frequently while being applied.

From one-eighth to one-half pint is sufficient for one application. To apply the mixture, a brush is used. We find nothing more satisfactory than a large painter's brush. At first it is well to make an application for two or three days in succession. Afterwards an application every other day will suffice. It is often more economical not to attempt to protect the entire animal, but only those parts not reached by the head or tail. It is perfectly safe, and in no case has it appeared detrimental to the health of the calf.

Farmers often object to the expense of handling calves in the way we have indicated. It does not take much time. Two hours a day was all the time needed to feed the calves in this experiment, and part of this was used for taking weights and making records. At the time of writing this bulletin we are feeding forty-five young calves, divided into five lots, and each lot fed a different way. It takes five hours a day, while if they were all fed alike, and each feed did not have to be weighed, much less time would be needed. It does not take much more time to feed a skim milk calf so that he will gain two pounds a day than it does to feed him so that he will become a runt, but it does take thinking, patience, and careful attention to the little things.

This experiment shows that calves can be easily raised on skim milk and fed and handled so that they will be thrifty, gain well, and be in good condition for the breeder or feeder.

EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN No. 98—MAY 1900.

HORTICULTURAL AND ENTOMOLOGICAL DEPARTMENT.

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SCALE-INSECTS UPON KANSAS GRASSES.

To THE student of other groups of injurious insects it may appear that the scale-insects have lately occupied more than a due proportion of the public interest. The unheralded advent of the San José scale, its unsuspected distribution over a wide territory, its rapid though insidious increase in a locality where it has once gained foothold, and its somewhat overrated though still very important position as an injurious species have combined to call the scales generally into greater prominence than they have hitherto enjoyed in any extra-tropical country.

These insects, belonging to the family Coccidæ, constitute a group of Homoptera of characters unusual in many respects when compared with insects in general. They differ not only in remarkable ways from other insects, but different species of the group vary within wide degrees among themselves, or even between the two sexes of the same species. In habits they are sedentary, in the most important forms the adult females especially being wholly without the power of locomotion. In the adult males alone are wings present, making possible the approach of this sex to the other at pairing time. All are small insects, and with most of them their systematic study can be carried

on only by the exercise of special skill in manipulation, and by the use of the best appliances.

The group thus presents many attractive features to the student of pure entomology. Their obscure structural characters, their hidden life-histories, and the abundance of new forms, heretofore unsuspected, offer inducements to their study of a kind most inviting to the entomological enthusiast; and that these facts have been appreciated is made evident by the recent considerable increase in the literature on the family.

To the student of economic entomology their study also appeals with especial force, as the members of this group throughout constitute destructive plant pests, of a character all the more dangerous in that they are individually insignificant, and so inconspicuous even in the mass that it requires expert eyes to distinguish them as insects as well as to identify the species. Along with this, their extreme fecundity, their uniformly unfavorable influence on all plants subject to their attacks, and the difficulty of their extermination by any of the customary methods employed in the case of better-known insects of this region, demand, from the strictly practical standpoint, the most assiduous and painstaking pursuit of methods for their destruction.

The scale-insects that have chiefly attracted the attention of students, at least in temperate regions and outside of conservatories, are parasites of the woody plants, mainly occupying the stems, branches, leaves or fruits of these plants above ground. Root-inhabiting forms exist, but it is not commonly the case that these inhabit the perennial herbaceous plants in the open ground in our country.

The object of the present paper is to call attention to the occurrence in Kansas, on common perennial prairie grasses, of certain species of the Coccidæ, in one group at least, of unexpected relationships. The genus *Antonina*, of which several new species are here described, has not hitherto been reported elsewhere from the United States, and this fact gives these forms additional interest.

It is undoubtedly true of the grass-inhabiting forms of the scale insects that they are like the others of the family in their power for injury to the infested plants, but it is fortunate that their occurrence is less common than that of their host-plants. However, the species occur, as will be noted in the following account, upon plants of great agricultural value, the grasses that they inhabit being well known and widely distributed species of the great grazing lands of the state.

The scales upon the grasses, like other Coccidæ, are in appearance quite different from insects of more familiar types, but with a little careful observation one may learn to detect them in spite of their deceptive forms. The most common and widely distributed of these

belong to the hitherto unreported genus *Antonina*, and are to be recognized at the base of the stems and the crown of uprooted grasses by the little cottony clusters, which, though smaller in size, present an appearance not unlike that of the common mealy-bug occurring on greenhouse plants, or of the woolly excretion of the well-known aphids or plant-lice upon the bark of the roots and trunks of apple trees. By removing this protective covering, a small, naked, stationary, cream-colored body, which is the adult female, is often exposed. Closely allied to the above are the *Eriococcus* forms, which differ in that the covering is more compact and felt-like, so that the insects in size and appearance resemble large swollen grains of rice. They are arranged longitudinally in irregular groups along the stems above the surface of the ground, or sometimes hidden between the stem and the leaf. By removing the sheathing leaves at the base of the stem, there are often found small brown bodies, somewhat irregular in shape and not unlike the bud-scales of a tree. These are scales belonging to the genus *Pseudolecanium*. Associated with these, there are present at certain seasons young white forms which resemble the beginnings of new shoots. The true nature of these forms can at once be detected by the fact that the insect may be readily scraped from the plant by a knife or the finger. Clustered at the base of the roots are the *Gymnococcus* forms, which are somewhat pear-shaped, and in appearance resemble the larvæ of the potato beetle. In the fall the specimens are naked, while in the spring they are often covered with a heavy mass of cottony threads. In either case they are easily detected, and when crushed stain the hands with their secretions.

The following table will be of assistance in classifying the various groups of scales upon the grasses, so far as they are considered in this paper:

Insects at the lower parts of the stems inclosed in a dense cottony covering, or felted sac, about one-eighth inch in length, which when fresh somewhat resemble swollen grains of rice.....**Eriococcus**

Insects dull terra-cotta red in color, plainly showing the division of the body into segments, and loosely attached to the base of the stems and roots. In the spring specimens are covered with a cottony covering which contains a number of pink-colored eggs.....**Gymnococcus**

Insects oval, hemispherical, quite frequently flattened, and of a dark brown color. They are to be found at the bases of stems protected by the blades.....**Pseudolecanium**

Insects with a white body, which is stationary and covered with a cottony mass somewhat like the mealy-bugs. They are usually present at the base of the stems.....**Antonina**

Insects at the base of the stems, living beneath a small circular, dark brown, film-like covering about 0.1 inch in diameter, which if raised with a pin or any sharp point is seen to protect a soft, stationary, cream-colored body, the insect itself, beneath.....**Aspidiotus marlatti**

Grass Coccids Recorded from the United States.

There is little definite knowledge of the extent of this group, particularly the native forms, references to the grass scales being scattered and meager, and quite often incomplete in important particulars. In the following list it has been the endeavor, so far as the limited literature at command has permitted, to bring together published records, from the United States, of this class of scales, with their host-plants. It will not be surprising if a number of species have been omitted.

Rhizococcus quercus Comstock; upon unnamed species of grass, Rept. U. S. Dept. Agric., p. 340, 1880.

Aspidiotus hederæ Vall., var. *nerii* Bouche; upon grass, name not given, Comstock, 2d Cornell Report, p. 63, 1883.

Chionaspis spartinæ Comstock; on *Spartina stricta*, 2d Cornell Report, p. 106, 1883.

Ripersia maritima Ckll.; on *Spartina*, sp., Insect Life, vol. VII, p. 43, 1894.

Orthezia graminis Tinsley; on culms and blades of grass, Can. Ent., p. 12, 1898.

Dactylopius sorghiellus Forbes; on roots of June-grass and timothy, King, in Can. Ent., p. 111, May, 1899.

Pseudolecanium californicum Ehrhorn; on bunch-grass, Can. Ent., p. 103, May, 1899.

Ripersia arizonensis Ehrhorn; in ants' nests on roots of grass, Can. Ent., p. 5. Jan. 1899.

Aspidiotus marlatti Parrott; on *Andropogon scoparius* and *Andropogon furcatus*, Can. Ent., p. 282, 1899.

Antonina nortoni Parrott and Ckll.; on *Bouteloua racemosa*, Can. Ent., p. 280, 1899.

Aspidiotus hederæ Vall.; on grass, King, in Can. Ent., p. 225, 1899.

Dactylopius citri Boisd.; on *Bouteloua eriopoda* in greenhouse, Parrott, MS.

List of Kansas Specimens, with Host-plants.

In the course of the field-work of the past summer, the Department of Entomology of this Station gave attention to the collection of scale insects from the prairie-grasses of the state, recording a number of new species and host-plants. These, together with the species already published for the state, are here appended, thus making the list of coccids upon Kansas grasses complete to date.

Species.	Host-plants.
Antonina bouteloues	Bouteloua hirsuta.
	Bouteloua havardii.
Antonina nortoni	Bouteloua racemosa.
Antonina graminis	Eragrostis trichodes.
	Eragrostis pectinacea.
	Bulbilis dactyloides.
	Paspalum ciliatifolium.

Species.	Host-plant.
Gymnococcus nativus	Sporobolus cryptandrus.
Aspidiotus marlatti	Andropogon furcatus.
	Andropogon scoparius.
	Panicum virgatum.
	Chrysopogon avenaceus.
Eriococcus kemptoni	Androgogon scoparius.
Pseudolecanium obscurum	Andropogon scoparius.
	Sporobolus longifolius.
Pseudolecanium californicum	Andropogon furcatus.

For the convenience of the general entomologist as well as the specialist, it seems well to reproduce in full the descriptions of *Antonina purpurea*, as well as that of *Gymnococcus agavium*, with the corrections and additional points of value as suggested by Douglas, the publications containing them being inaccessible to many entomologists. Their incorporation in this publication is further desirable as making the present account of these genera quite complete.

In the preparation of this paper we desire to express our appreciation of the assistance rendered by Messrs. J. B. Norton and H. B. Kempton in their careful work in collecting, and by the former more particularly in the determination of the grasses. We are especially under obligations to Prof. Theo. D. A. Cockerell for many valuable suggestions and for the gift of a number of closely allied species, for the loan of mounts of types, and for the description of *Antonina purpurea*, translated by his wife. We are also indebted to Mr. C. L. Marlatt for a copy of Lichtenstein's description of *Antonina brachypodii*, and to Mr. E. M. Ehrhorn for topotype specimens of *Pseudolecanium californicum*.

Studies of Grass Coccids, with Description of New Species, by P. J. Parrott.

ANTONINA.

Antonina Signoret, Annales de la Société Entomologique de France, vol. V, 1875, pp. 25–27.

Adult females inclosed in a cottony sac; apodous, with or without antennæ, excreting from the abdomen a very long cottony appendage; anal ring with six hairs. Larva with six-jointed antennæ.

TABLE OF SPECIES.

1. Anal orifice deeply invaginated, protected on ventral surface by a chitinous plate.....**boutelouæ**
   Anal orifice not so.....2
2. Antenna short, aborted, with not more than three segments.....3
   Antenna with five segments, occasionally four.....**graminis**
3. Derm, exclusive of anal segment, with a large number of hairs.....**purpurea**
   Derm not so.....**nortoni**

Antonina bouteloues, n. sp. (Plate I, figs. 2, 3, 4, 5, 6; plate V, fig. 3.)

Sac white, cottony, 3 mm. long, 2 mm. wide. Living female oval in form and cream-colored. Specimens boiled in KOH clear easily, with the exception of the spiracles, mouth-parts, antennæ, and more especially the ultimate segment, which remains strongly chitinous, and of a dark yellowish-brown color. Small round glands in all parts of the body, more numerous in the caudal region. About anal area, a number of small sharp spines and many slender hairs. Antenna short, thick, composed of three segments. Spiracles strongly chitinous, surrounded on the outer margin by a crescentic group of rather large round glands. Anal orifice large, deeply invaginated, and protected on the under side by a large chitinous plate.

Larva about .5 mm. long by .2 mm. in width, oval in form. In KOH, is yellowish, with the legs and mouth-parts darker. Anal ring of medium size, with six stout bristles. Lateral of anal opening, one long slender hair, with several small sharp spines at its base. On the transverse middle of each segment, a row of short conical spines. Legs stout, chitinous, with tarsus and tibia subequal; tarsal digitules long, filiform. Antenna six-segmented, measuring as follows, in micromillimeters, respectively: (1) 17, (2) 14, (3) 13, (4) 8, (5) 10, (6) 49.

Habitat.—Collected by H. B. Kempton, May, 1899, at the base of stems of *Bouteloua hirsuta*, growing on the sand-hills south of Manhattan, Kan.

A specimen closely resembling this species was found by J. B. Norton in the collections of the Botanical Department upon *Bouteloua havardii*, "Limpia canyon, Texas, G. C. Neally, '89." It resembles *bouteloues* in the peculiar structure of the anal orifice, but differs in the small disc-like spiracles. More specimens are needed to insure a correct determination of the species.

Antonina purpurea.

Antonina purpurea Sign., Annales de la Société Entomologique de France, vol. V., 1875, pp. 25–27.

*Laboulbenia brachypodii** Licht., Mittheilungen der Schweizerischen entomologischen Gesellschaft, Nov. 1877, Band V, Nr. 5.

Antonina brachypodii Ckll., Check-list of the Coccidæ, Bull. Ill. State Lab., vol. IV, art. XI.

This species, of the length of 2 to 3 mm., by 1 mm. in width, is enclosed, in the most advanced state, in a padded sac, like *Eriopeltis festucæ*, but forming a smaller heap, and being found either above the neck of the plant in the open air, or on the root.

*Lichtenstein, in a postscript to his mention of *Laboulbenia brachypodii*, expresses an opinion that his species is identical with *Antonina purpurea*. I have therefore made *brachypodii* a synonym. His description of the species is of itself not sufficient for any satisfactory determination.

In the first case, one notices that from the superior point of this sac the insect emits a long silky conduit, which is secreted by the abdominal extremity which corresponds to this point. The insect is then head downwards. If one opens the sac, it appears as a mass, of an elongated cylindrical form, blackish, which, crushed, tints the fingers with dark red. In this stage it sufficiently resembles a dipterous pupa, all the more that on examination it is quite impossible to see the legs, which have disappeared.

The superior extremity is rounded and allows to be seen the vertices of the antennæ, which present a few visible articulations, the last with five or six hairs, almost spinous; the inferior is a little less wide, narrower than the body, and offers a considerable thickening of the derm, which, besides, is more colored and strongly punctuate with rugose points. A little before the edge a wide genito-anal ring, with six very long hairs, but which do not exceed the abdomen; on each side we can distinguish two lobes with some hairs, which are prolonged even on the segment; amidst the punctuation are seen a few short hairs. On the derm after it has been decolored by potassium one sees above a great number of spinnerets in the form of hairs, and with a rounded punctuation. Below it seemed to us that these were only hairs. On each side one easily sees the stigmata, which are colored, and accompanied by an abundant punctuation. The rostrum offers a pretty long insertion, with the rostral filaments very long—the curve attaining almost the last abdominal segment; these are not very visible, except the last ones of which the suture presents some rugose-colored points. The lower lip or chin we found difficult to isolate, and we could not say if it is multiarticulate in the adult insect advanced in age; but with the embryonic larva we were quite well able to isolate and draw it, and it is formed of two articulations, which helped us to class this species with the coccids and not with the lecaniids. In this stage we found the antennæ of six joints, of which the sixth is the longest, the others short and nearly equal. The legs are thick, slightly pubescent; the tarsus equals the tibia as to length, the claw is long, with the four usual filiform digitules. What struck us most in this larva was the extraordinary length of the rostral filaments, which unfolded would exceed three to four times, or even more, the length of the body.

Habitat.—It is found on the stubble and at the root of certain of the Gramineæ, principally *Milium* and *Agropyrum*, and by its position and habitat gives cause for the idea that it might be *C. radicum-graminis* of Geoffroy or Fonscolombe.

Antonina nortoni. (Plate I, fig. 5; plate V, fig. 4.)

Antonina nortoni Parrott & Ckll., Can. Ent., Oct. 1897.

Sac white, cotton-like, completely enveloping female. Female oval, plump, cream colored, with slight tinge of brown on margin. There are many single glands, especially in the caudal region, but they are less numerous anteriorly. On outer side of each spiracle there is a crescentic group of rather large circular glands, placed very close together. Antennæ short, thick, composed of three segments, measuring respectively 18–25, 13–16, 27–28 micromillimeters. Spiracles chitinous, large and extended. Anal orifice circular, situated in a slight depression, surrounded by a strong chitinous ring. Around anal area are many slender hairs, very much smaller than bristles of the anal ring.

Habitat.—Found at the bases of the stems of *Bouteloua racemosa*, on Bluemont, Manhattan, by J. B. Norton, April 25, 1899.

Antonina graminis, n. sp. (Plate I, fig. 6; plate IV, fig. 1.)

Sac of female globular, dirty white, 3 mm. in diameter. Female oval in form, of a light brown color, slightly pollinose, 2.6 mm. in length, 1.4 mm. in width. Specimens are rather difficult to clear in KOH, almost invariably retaining a yellowish coloration. Derm is heavily punctuated with many small round glands, especially in the caudal region. A few short slender bristles are present in all parts of the body, but are more numerous on the posterior segment. Anal orifice quite large, with six stout bristles, surrounded by a strong chitinous ring. In the caudal area are a small number of bristles, more slender, and a little shorter than those in the anal orifice. Spiracles large, chitinous, surrounded on the outer margin by small oval and round glands, about forty in number, situated closely together in a crescentic group. Antennæ rather short and thick, consisting of four or five segments, measuring, respectively, in micromillimeters: (1) 21, (2) 23, (3) 21, (4) 27, and (1) 14, (2) 21, (3) 12, (4) 7, (5) 25. The three basal segments are usually broad, of about the same width, while the last two segments taper sharply. In some specimens the anterior legs were present; these were thick and not very chitinous; femur longer than tibia, and tibia longer than tarsus.

Habitat.—Collected at the base of stems of *Eragrostis trichodes* by J. B. Norton, May 30, 1899, at St. George; upon *Bulbilis dactyloides* on sand-hills south of Manhattan; upon *Eragrostis trichodes*, *E. pectinacea*, *Paspalum ciliatifolium* on sand-hills south of Hutchinson; and upon *Eragrostis trichodes*, Nickerson, Kan., by H. B. Kempton, August, 1899.

This species resembles *nortoni*, but is distinguished at once from it by the peculiar antennæ. For the reason that legs appear in a number of specimens, I hesitated at first in placing it in this genus, but prefer to do this temporarily rather than construct a new genus, which seems to be my only alternative.

GYMNOCOCCUS.

Gymnococcus Newstead, Ent. Mo. Mag., 2d series, vol. VIII.

Female adult forming a cottony sac; body soft, naked. Legs highly chitinized, tarsus generally longer than the tibia; anal ring with six short bristles placed in two groups on its anterior lateral margins. Anal lobes absent.

TABLE OF SPECIES.

1. Derm of female with numerous short conical spines.....**agavium**
   Derm of female smooth, without spines.....2
2. Glands around spiracles in a crescentic group.....**nativus**
   Glands around spiracles forming a circle.....**ruber**

Gymnococcus agavium. (Plate II, fig. 4.)

Coccus agavium Douglas, Ent. Mo. Mag., Dec. 1888.
Gymnococcus agavium Newstead, Ent. Mo. Mag., 2d series, vol. VIII.

Female adult: Short rounded oval, a little narrower in front, smooth, without mealy or cottony covering, very convex and firm on upper side, pinky-yellowish, with some light brown specks on the back, somewhat in two longitudinal rows, beneath soft and very tumid; segmentation visible above and beneath; anal ring of six hairs, the chitinous portions in three equal parts, each separated from the other; the orifice never circular, but crescent-shaped as in the genus *Coccus*. Legs short, chitinous, and scarcely longer than the antennæ; tarsi longer than tibiæ. Antennæ short, stout, tapering, of seven joints, highly chitinous, with wide articulations; 1st joint longest; 2d, 3d and 4th nearly as long, subequal; 5th, 6th and 7th each consecutively shorter and smaller, and having a few hairs; 5th joint with a spine. Mentum biarticulate. Derm above, with numerous short conical spines. Anal lobes obsolete, in their place a long hair. Larva clearly dactylopid. Anal lobes obsolete. Anal ring as in the adult, but all the parts proportionally smaller. Dorsum with six rows of short conical spines, not truncate as in *Coccus*.

Male adult: Blackish brown, shining; head broadly produced anteriorly; antennæ long, slender, piceous, with projecting simple hairs, of ten joints; the first two thick, 1st longest of all, narrow at base; 2d

oval, twice as long as the first; the 3d to 5th thinnest, 3d longest of all; 4th and 5th one-fourth shorter, subequal; 6th to 10th stouter; 6th as long as 2d; 7th shorter; 8th and 9th still shorter, subequal; 10th shorter than 9th, conical. Eyes simple, an ocellus vertical and close to the margin of each. Thorax broad, convex, sides divergent to an angle, posterior angles prominent; posterior depression large. Wings very long, ample, clear white, halteres short, white. Terminal filaments of the body long, white. Legs long, slender, piceous, with short, projecting, simple hairs; tibiæ very long; tarsi one-fourth as long as the tibiæ, claws very short. Pupa in a close-fitting sac made by the larva. Length, 1 mm.

Habitat.—From the under side of leaves of a species of agave from the Royal Gardens, Kew.

Gymnococcus ruber. (Plate II, figs. 2, 3, 6; plate IV, fig. 2.)

Gymnococcus ruber Parrott & Ckll., Industrialist, March, 1899.

Female more or less pyriform, 6 mm. long, and about 4 broad, soft, naked, slightly pruinose, with a very little white secretion on the under side; color dull terra-cotta red, very much the color of the larvæ of *Doryphora* 10-*lineata* or of red modeler's wax. Surface somewhat shining. Segmentation obscure in adults, but very distinct in younger forms (3 mm. long), which are flattened, nearly circular in outline, and look like Maskell's figure of the adult female of *Dactylopius poæ*.

Boiled in KOH, the insect gives a fine crimson color and becomes quite transparent, except that the legs, antennæ, anal ring and mouth-parts remain brown. Skin with rather numerous small round glands, especially in the caudal region; these glands, focused up and down, sometimes look like short spines. In the cephalic region there are a very few true spines, small and slender. Anal ring very small, subcircular or oblong, strongly chitinous, with six very short bristles, in two sets of three, confined to the anterolateral parts of the ring; mouth-parts small, the so-called mentum distinctly dimerous; legs and antennæ strongly chitinized; antennæ short and rather stout, seven-segmented; segments 1, 2, 3, 4 and 7 subequal, each about 33 micromillimeters long; 5 and 6 subequal, each about 25 micromillimeters long.

Egg oval, yellow to pinkish red, depending upon the development of the embryo, slightly pollinose, about 340 micromillimeters in length by 216 in width. The eggs are deposited in a cottony mass, secreted by the female. Often one-half to three-quarters of the insect is covered by a loose mass of cottony threads. One ovisac examined

contained over 400 eggs, besides a large number of larvæ. On January 27 specimens were commencing to form ovisacs, from which larvæ were seen to emerge March 12.

Larva purplish; legs and antennæ light yellow. Caudal tubercles prominent, with one long filament each, of a length not exceeding one-half that of the body. On each side of the base of the filament one short stout spine. On each segment a transverse row of short stout spines. Antennæ six-segmented, gently tapering, measuring in micromillimeters as follows: (1) 9, (2) 14, (3) 21, (4) 10, (5) 13, (6) 24. Legs stout; femur 70 micromillimeters in length, tibia 47, tarsus 56.

Habitat.—In clumps of *Bouteloua eriopoda*, hidden at the bases of the stems, at Mesilla Park, New Mexico.

Gymnococcus nativus, n. sp. (Plate II, figs. 5, 6; pl. VI, fig. 6).

Female, adult 3 mm. long, 2 wide, soft, naked, varying from short rounded oval to pyriform in shape; color dull terra-cotta red, resembling *ruber*. Segmentation quite distinct above and below. Boiled in KOH, the female gives a bright crimson color, and becomes quite transparent, with the exception of the antennæ, legs, mouth-parts, and anal ring, which remain brown. Derm with many small round glands in the caudal region, but with fewer numbers in anterior segments; large oval glands, often elongated oval, few in number, in all parts of the body. A few small slender spines are to be seen, especially around the anal ring and mouth-parts. Exterior portion of spiracle circular, disk-like, surrounded on its outer margin by small round glands, from twelve to twenty in number, placed close together in a crescentic group. Anal ring small and circular, strongly chitinous, and containing six very short stout bristles, arranged in two groups on its anterior lateral margins. Legs stout; tarsi longer than tibiæ. Antennæ seven-segmented; segments 1, 2, 3, 4, 7 subequal, measuring from 17 to 35 micromillimeters in length; 5 and 6 subequal, considerably shorter than the former.

Habitat.—Collected at the base of stems of *Sporobolus cryptandrus* by H. B. Kempton, August, 1899, at Nickerson, Kan.

Aspidiotus marlatti. (Plate II, fig. 1.)

Aspidiotus marlatti Parrott, Can. Ent., Oct. 1899.

Found upon the bases of stems of *Andropogon furcatus*, *A. scoparius*, *Panicum virgatum*, and *Chrysopogon avenaceus* (J. B. Norton).

Eriococcus kemptoni, n. sp. (Plate I, fig. 1; plate V, fig. 5.)

Sac of female about 3 mm. long and 1.5 mm. wide, varying from white to yellowish in color, firm and closely felted. Female oval in form, about twice as long as broad, dark yellow to almost orange in color, segmentation complete. Boiled in KOH, female turns to a crimson, and clears quite readily. In the space between the antennæ and the mouth-parts, four to six stout spines placed in a transverse row. Along the margin, extending from the anal ring and not reaching the point of attachment of the posterior legs, from seven to ten stout spines. Derm when transparent reveals a number of small round glands, especially about the mouth-parts and the caudal region; in these parts small spines are also present. Posterior tubercles with one long hair. Anal ring quite large, with eight bristles. Legs large and stout; femur quite swollen, measuring with trochanter from 130 to 140 micromillimeter; tibia generally shorter than tarsus, measuring from 81 to 98; tarsus, from 84 to 105. There is one stout bristle on inner margin of the tibia near distal end, and several smaller ones on distal end of tarsus. Antennæ seven-segmented, with the segments quite variable. A number of formulæ were as follows: 13 (47) 265, 4 (317) 256, 3 (147) 256, and 7 (321) 456.

Habitat.—Collected by J. B. Norton on *Andropogon scoparius* in Moehlman Bottom, June 1, 1899, Riley county, and also by R. H. Kempton on *Andropogon scoparius*, August, 1899, at Dundee, Kan.

Pseudolecanium obscurum, n. sp. (Plate III, figs. 1, 2; plate VI, fig. 7.)

Females irregular in size, varying from 2 to 7 mm. long, 1.5 to 3 mm. wide, some globular, others extremely flat; young forms from cream to pink in color, shining, the posterior segment darker colored, often black. Not infrequently the dorsum is longitudinally striated by the veins of the leaves of the host-plant.

Boiled in KOH, female becomes transparent, with the exception of the mouth-parts, spiracles, and the posterior segment; mouth-parts small, complete; spiracles, two pairs, large, somewhat resembling the shape of a dumb-bell with flattened ends, the exterior portion disk-like, the margin composed of a strong chitinous ring, the inner surface composed of many circular glands. Parallel to the margin, on the outer side of the mouth-parts and spiracles, but contiguous to the latter, are a large number of glands varying in size, with a chitinous margin, and forming a band around the body, which is at its greatest width in the region of the spiracles, where there are four or five rows of glands; while about the mouth-parts there are only one or two rows of glands; on the posterior segment the glands are closer

together, and when viewed sidewise appear like small blunt spines. This is best seen when the band of glands comes in contact with the margin of the segment.

Posterior segment very chitinous, with a rather large number of circular glands; margin neither plicate nor crenate, quite even, with the exception of the deep cleft at the middle. The tips of the anal lobes have four or five small bristles each. Anal ring with a number of slender hairs.

Habitat.—At the bases of the stems of *Andropogon scoparius* from Lost Springs, Parsons, Fredonia, and upon *A. scoparius* and *Sporobolus longifolius*, Green Mound, Oct. 28, 1899 (Parrott).

This species is distinguished from *californicum* by the absence of the row of thick blunt spines on margin and by the presence of very chitinous spine-like glands on the margin of the posterior segment.

Pseudolecanium californicum Ehrhorn. (Plate III, figs. 3, 4, 5.)

Nidularia (*?*) *californica* Ehrhorn, Can. Ent., May, 1899.
Pseudolecanium californicum Ehrhorn, MS.

Female adult dark brown, 2 to 5 mm. long, 1.5 to 3 mm. wide, with the ultimate segment darker and more chitinous. Specimens vary much in size and shape. Young forms cream to pinkish in color, with the anal segment from dark brown to black; derm smooth, shining, with slight traces of whitish secretion. All stages rest upon a thin white secretion, which in old specimens is quite brittle. No antennæ visible, but in one specimen the anterior pair of legs was present. These were slender, not very chitinous, measuring as follows, in micromillimeters: Femur, 98; tibia, 56; tarsus, 48. Along the margin of body there are several rows of glands. Interspersed among these glands are a number of blunt spines, some of which resemble a spear-head set in a socket, and others little acorns. Few short sharp spines are to be seen here and there in all parts of the body. Margin of posterior segment very chitinous, plicated, and deeply cleft in the middle.

Habitat.—At the base of the stems of *Andropogon furcatus* upon sand-hills south of Manhattan (Parrott), and near St. George (J. B. Norton).

The Kansas specimens vary from the typical *californicum* in the arrangement of the blunt spines along the margin. In our mounts of specimens of *californicum*, kindly sent us by Mr. Edw. Ehrhorn, the row of spines is quite constant; but in the local specimens the spines are not confined to a row, but are distributed among the rows of glands, and, as shown in the drawing, the spines often exceed the cir-

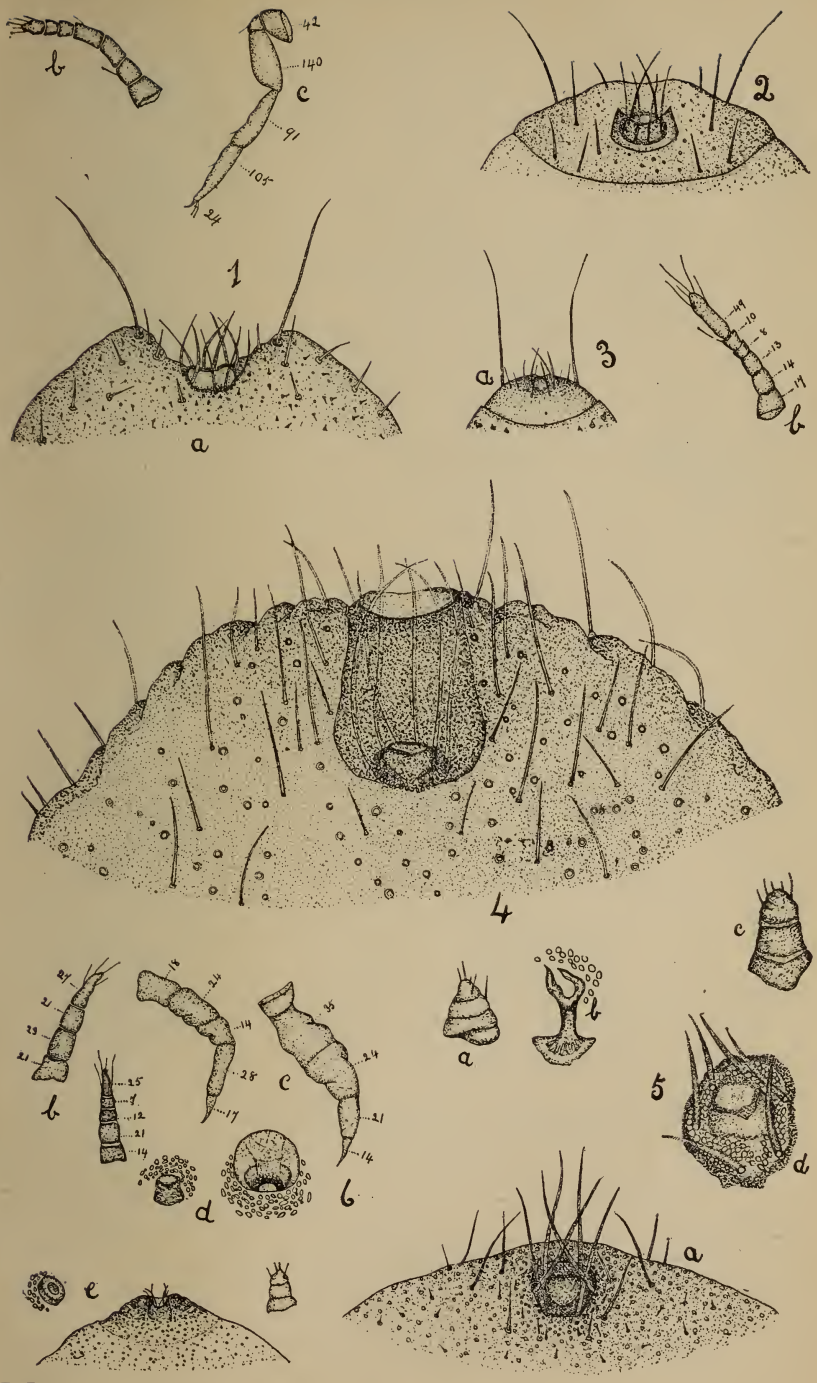
cular glands in number; in some specimens the spines are scarcely apparent. In all other respects the Kansas specimens agree well with *californicum.* In his description, Ehrhorn speaks of the spines as resembling the shape of a spearhead set in a socket. In our mounts they more resemble acorns. An examination of a large number of mature and immature forms of both lots, which we do not possess, would undoubtedly clear up these slight differences.

PLATE I.

Fig. 1.—Eriococcus kemptoni.
a. anal ring of female.
b. antenna of female.
c. leg of female.
Fig. 2.—Anal segment of immature female of Antonina bouteloueæ.
Fig. 3.—Antonina bouteloueæ.
a. anal segment of larva.
b. antenna of larva.
Fig. 4.—Antonina bouteloueæ.
anal ring of female.
Fig. 5.—Antonina bouteloueæ.
a. antenna of female.
b. spiracle of female.
Antonina nortoni.
c. antenna of female.
d. anal ring of female.
Fig. 6.—Antonina graminis.
a. anal ring of female.
b. antennæ.
c. legs.
d. spiracles.
Antonina bouteloueæ, from Texas.
e. anal segment, antenna and spiracle.

All figures greatly enlarged.

PLATE I.



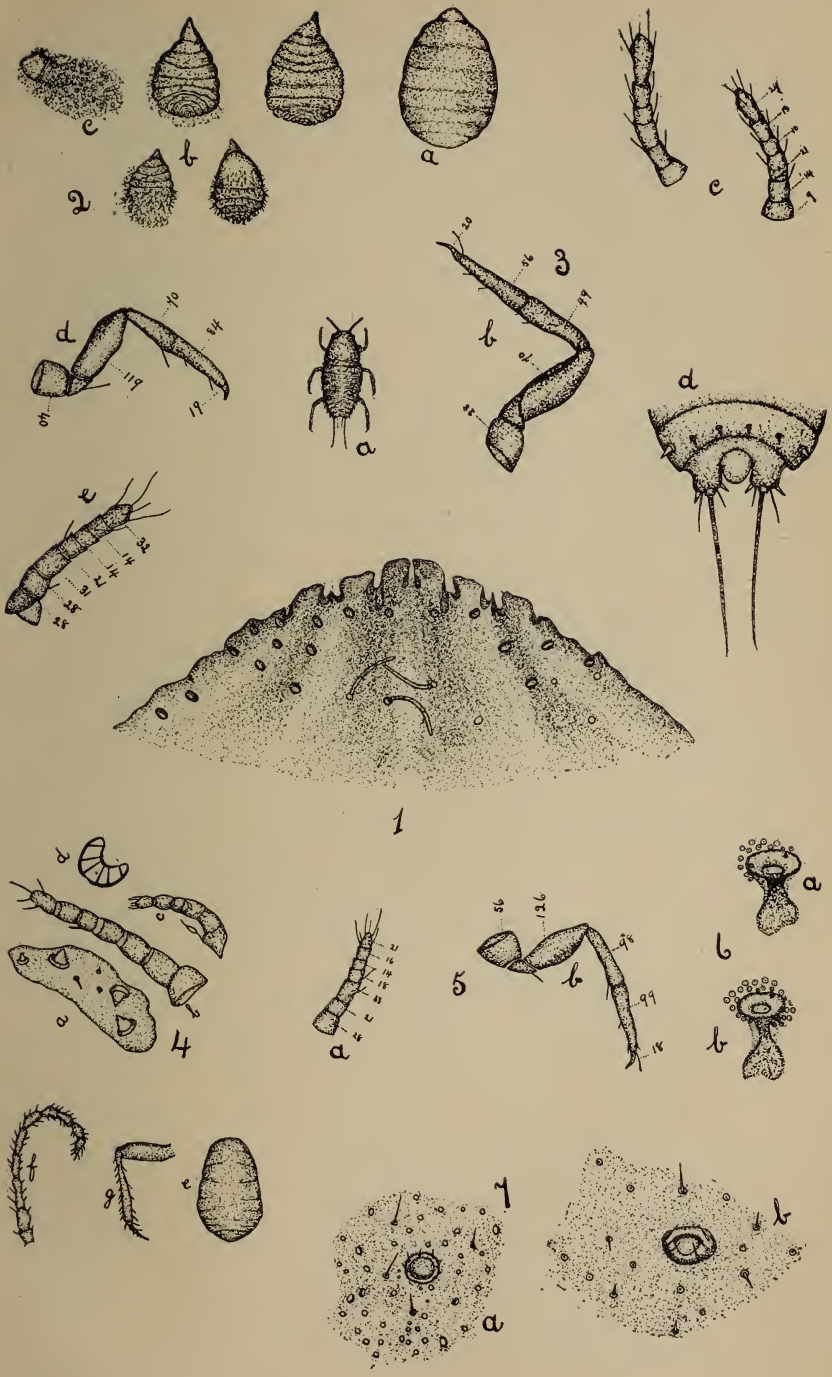
P. J. Parrott, del. ad nat.

PLATE II.

Fig. 1.—Aspidiotus marlatti.
anal segment of female.
Fig. 2.—Gymnococcus ruber.
a. adult female.
b. female with slight cottony secretion.
c. female with ovisac.
d. leg of female.
e. antenna.
Fig. 3.—Gymnococcus ruber
a. larva.
b. leg of larva.
c. antennæ.
d. anal segment.
Fig. 4.—Gymnococcus agavium.
a. derm of female with short conical spines.
b. antenna.
c. antenna of larva.
d. anal ring of female.
e. female.
f. antenna of male.
g. leg.
Fig. 5.—Gymnococcus nativus.
a. antenna of female.
b. leg.
Fig. 6.—Gymnococcus nativus.
a. spiracle.
Gymnococcus ruber.
b. spiracle.
Fig. 7.—Gymnococcus nativus.
a. anal ring.
Gymnococcus ruber.
b. anal ring.

Fig. 4 adapted from Douglas and Newstead.
All figures greatly enlarged.

PLATE II.



P. J. Parrott, del. ad nat.

PLATE III.

Fig. 1.—Pseudolecanium obscurum.
a. anal segment of female.
b. section of derm with glands.

Fig. 2.—Pseudolecanium obscurum.
a. larva.
b. antenna of larva.
c. leg.
d. anal segment.

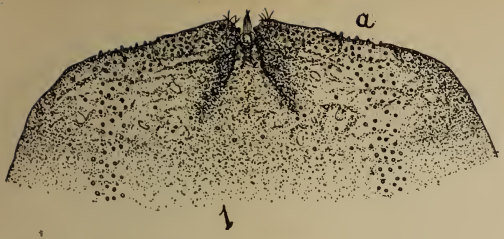
Fig. 3.—Pseudolecanium californicum.
anal segment of female.

Fig. 4.—Pseudolecanium californicum.
a. section of margin of larva, showing lateral spines.
b. antenna of larva.
c. leg.

Fig. 5.—Pseudolecanium californicum.
a. leg of adult female.
b. section of derm from local specimens, showing arrangement of glands and spines.
d. section of derm from California specimens, with glands and spines.

All figures greatly enlarged.

PLATE III.



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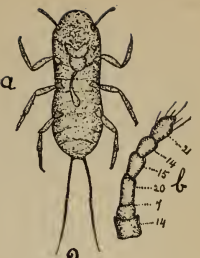

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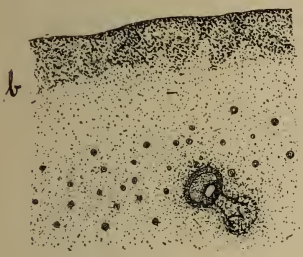

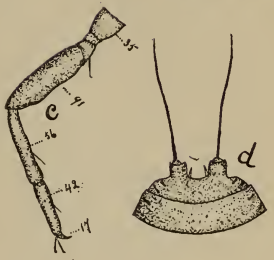

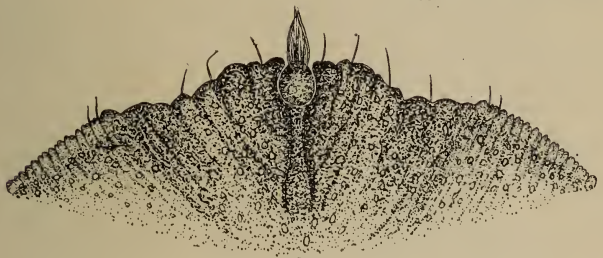

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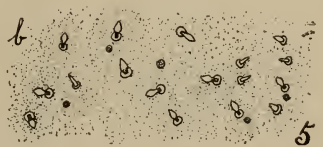

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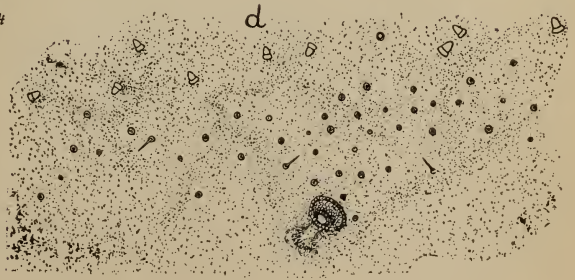

P. J. Parrott, del. ad nat.

PLATE IV.

Fig. 1.—Antonina graminis upon Eragrostis trichodes.
Fig. 2.—Gymnococcus ruber upon Bouteloua eriopoda.

Magnified two diameters.

PLATE IV.

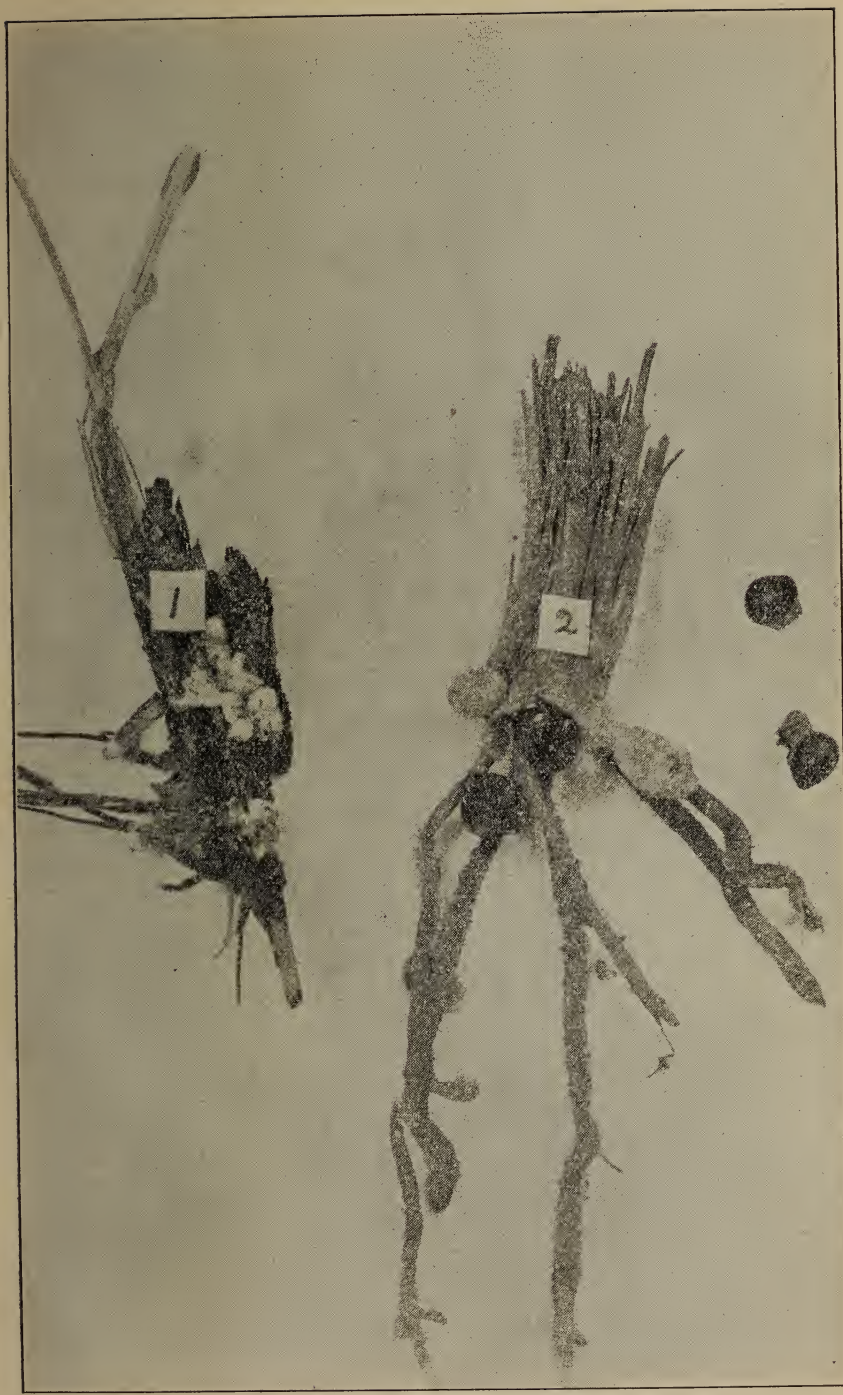

Photo from nature, magnified two diameters.

PLATE V.

Fig. 3.—Antonina bouteloueæ upon Bouteloua hirsuta.
Fig. 4.—Antonina nortoni upon Bouteloua racemosa.
Fig. 5.—Eriococcus kemptoni upon Andropogon scoparius.

Magnified two diameters.

PLATE V.

Photo from nature, magnified two diameters.

PLATE VI.

Fig. 6.—Gymnococcus nativus upon Sporobolus cryptandrus.
Fig. 7.—Pseudolecanium obscurum upon Andropogon scoparius.

Magnified two diameters.

PLATE VI.

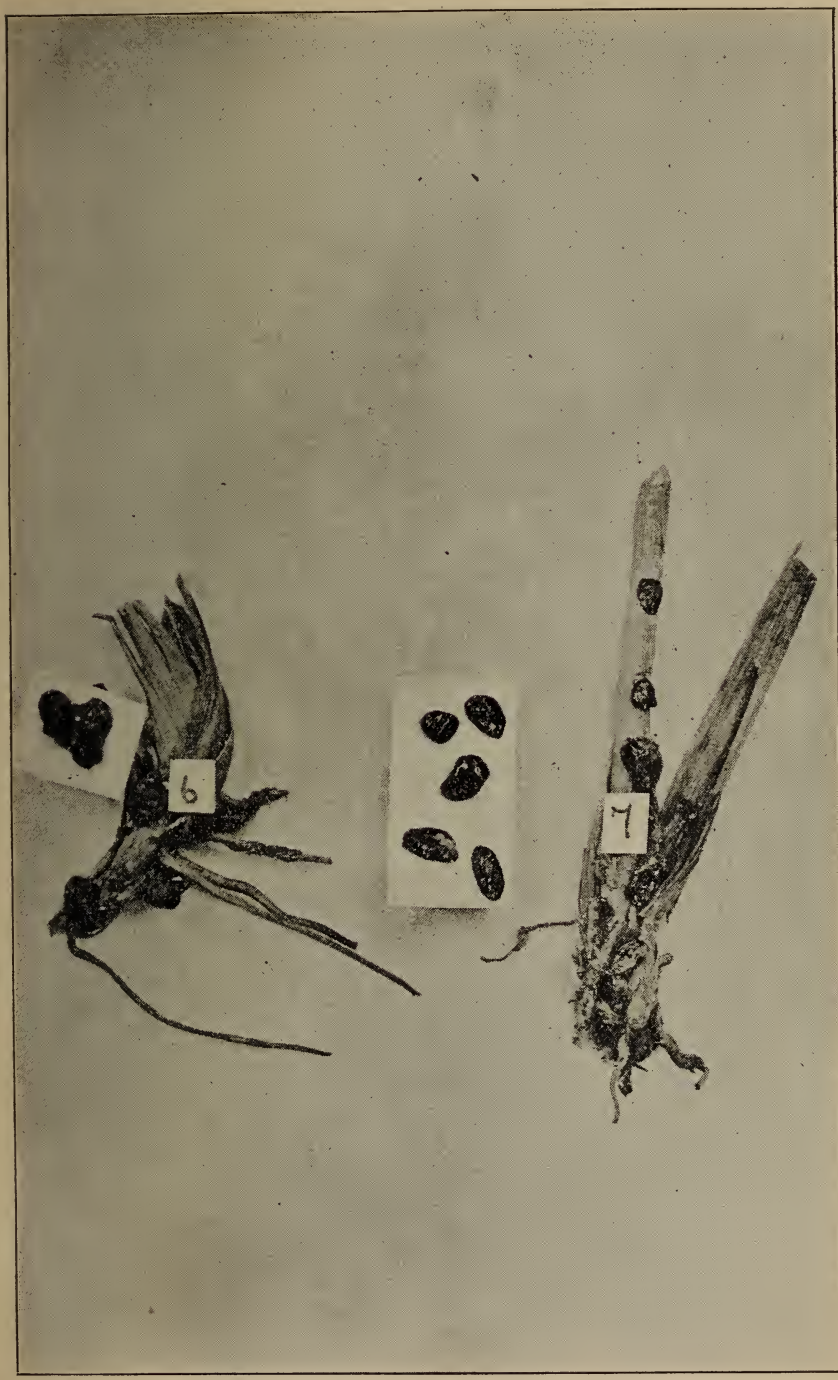

Photo from nature, magnified two diameters.

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